CDM Smith

Memorandum

To: *Dave Stewart, Steve Hann*

From: *John Aldrich*

Date: *December 23, 2014*

Subject: *LTCP Approach*

Executive Summary

Extensive water quality monitoring and analysis has been conducted on the two waterbodies receiving direct discharges from CRW's CSOs – the Susquehanna River and Paxton Creek – over the past 10 years. This data has been collected by CRW (for preparation of the 2005 LTCP), USEPA (for preparation of the 2008 Paxton Creek TMDL), and by PaDEP / Susquehanna River Basin Commission (via the relatively long-term Water Quality Network and over the past three years as part of the Susquehanna River Study). In addition, CRW's CSOs lie within the Chesapeake Bay watershed, perhaps the most studied waterbody in the United States.

Pollutants of Concern Discharging from CRW's Combined Sewer System

Pollutant of Concern	Susquehanna River	Paxton Creek	Chesapeake Bay
Sediment		●	●
Bacteria	●	●	
Dissolved Oxygen / BOD		●	
Nitrogen / Phosphorus			●

This data and analysis has identified the sources and levels of designated use non-compliance within Paxton Creek, indicating that stream erosion-induced sediment, DO/BOD, and bacteria/ pathogens are the pollutants of concern for CSO control in Paxton Creek. The Paxton Creek TMDL establishes load reduction targets for sediment / erosion for all dischargers in the watershed, and states that CRW's LTCP will be sufficient to address DO/BOD. In addition, physical channel alterations along most of Paxton Creek receiving CSO discharges, such as the Wildwood Lake impoundment and the concrete lining downstream of Maclay St., represent a significant, potentially permanent barrier to use attainment. Sources and levels of non-compliance within the Susquehanna River are somewhat uncertain as DEP's Susquehanna River study proceeds, however the data appears to indicate that CRW's CSOs present a limited threat to designated use impairment, with the possible exception of human pathogens / bacteria periodically limiting recreational uses. County-wide load allocations for nutrients and sediments have been developed under the Chesapeake Bay program, but have not been further allocated to individual pollutant sources.

Following review of this data, CRW has concluded that there is limited value to additional collection of water quality data and evaluation of in-stream water quality conditions solely for the purpose of developing CRW's LTCP. Previous sampling determined that CRW's CSO discharge concentrations can be characterized by national averages. Typical year and typical event pollutant load estimates and reductions can be determined through these characteristic pollutant concentrations and CSO discharge volumes determined through hydraulic modeling of CRW's conveyance system (e.g., interceptors and regulators). CSO load / load reduction projections may then be compared with load reduction targets established under the TMDLs, and / or used to evaluate instream conditions using bacteria transport / die-off and/or DO sag evaluations.

Based on these available water quality data and evaluations, CRW believes that CSO LTCP development according to the presumptive approach "would probably meet" water quality standards (*CSO Guidance for Long-Term Control Plan*, USEPA, 1995). Definition of the actual level of control under the presumptive approach will be determined through cost-effectiveness evaluations of a range of control levels, as specified in the partial consent decree. CRW would entertain a collaborative approach to evaluating watershed-wide water quality conditions within Paxton Creek, pending coordination on MS4 TMDL compliance plans, and/or in conjunction with DEP / SRBC related to the ongoing study of the Susquehanna River. CRW requests further collaboration with DEP regional and headquarters staff regarding the appropriate use and interpretation of available receiving water data and on-going evaluations to further evaluate the merits of such collaboration.

Introduction

The Draft Partial Consent Decree between Capital Region Water (CRW), the City of Harrisburg, the United States of America, and Pennsylvania DEP, requires that "*by December 30, 2014, CRW shall coordinate with EPA and PADEP to determine what approaches to LTCP Alternative Evaluation (i.e., Presumptive or Demonstration) are appropriate for each of CRW's Receiving Waters, and what the pollutants of concern are in each Receiving Water, to be determined consistent with EPA's "Guidance for Long-Term Control Plan," EPA 832-B-95-002, September 1995*". As part of this coordination, the Draft Partial Consent Decree requires CRW to "*. . . propose an approach for each of its Receiving Waters . . . present qualitative and quantitative information supporting the reasonableness of the proposed presumption criteria . . .*" and "*. . . review existing water quality data and recent PADEP Clean Water Act Section 303(d) listings to identify pollutants of concern*". This memorandum provides the requested information.

Identification of Waters Receiving CRW CSO Discharges

CRW's combined sewer system drains stormwater and wastewater from approximately 2,464 acres within the City of Harrisburg, or approximately 50 percent of the City's land area. The following Waters of the Commonwealth directly receive discharges from CRW's combined sewer system:

- The entire east shore of the Susquehanna River within the City of Harrisburg

- The main stem of Paxton Creek from its confluence with the Susquehanna River upstream to approximately the southern border of Harrisburg Area Community College, and excluding the portions of Asylum Run within the City.

CRW's combined sewer system also lies within the Chesapeake Bay watershed, and is subject to the objectives of the Pennsylvania Chesapeake Watershed Implementation Plan.

Summary of PADEP CWA Water Quality Assessments

Under the Clean Water Act (CWA), the Pennsylvania Department of Environmental Protection (PaDEP), Bureau of Point and Non-Point Source Management is responsible for establishing designated uses of each receiving water, establishing standards for measuring if these designated uses are attained, routinely assessing the attainment status of each receiving water and, where necessary, defining requirements for achieving future attainment. This section defines the current attainment status of the waters receiving discharges from CRW's combined sewer system.

Designated Uses of Receiving Waters

Chapter 93 of the Pennsylvania Code defines designated uses of the Waters of the Commonwealth and the Water Quality Standards (WQS) for each use. Both the segments of the Susquehanna River and Paxton Creek receiving discharges from CRW's combined sewer system have been assigned the same designated uses:

Aquatic Life:	Warm Water Fishery (WWF), Migratory Fishes (MF)
Water Supply:	Potable (PWS), Industrial (IWS), Livestock, Wildlife, Irrigation
Recreation:	Boating, Fishing, Water Contact Sports (WC), Aesthetics

The following water quality standards apply to these designated uses:

- General Criteria: Control floating materials, oil, grease, scum and substances that produce color, tastes, odors, turbidity or settle to form deposits.
- Specific Criteria: The constituent concentration listed in Chapter 93 should not be exceeded. **Table 1** provides a partial list of constituents most applicable to CSO control.

In applying these water quality standards, Pennsylvania Code Chapter 96 states that water quality standards "*... shall be achieved in all surface waters at least 99% of the time, unless otherwise specified in this title*", and that general water quality criteria "*... shall be achieved in surface waters at all times at design conditions*". This criterion applies to the development of Total Maximum Daily Loads (TMDLs) and Water Quality-Based Effluent Limitations (WQBEL), and is relevant to episocic wet weather discharges, which occur at varying magnitudes, durations, and frequencies.

Pennsylvania Integrated Monitoring and Assessment Report (formerly 305(b) Report) / Integrated List of All Waters (formerly 303(d) Report)

Every two years, PaDEP is required to assess the current state of attainment of the Waters of the Commonwealth, and report its findings in an Integrated Monitoring and Assessment Report (Integrated Report), as required under Section 305b of the CWA. In addition, waters that are not in attainment for one or more designated use categories are identified, as required under Section 303(d) of the CWA. TMDLs are then scheduled for waters on the 303(d) list that are not projected to meet WQS under current permit limits.

Table 1. Ambient Water Quality Standards for Designated Uses of Pennsylvania Waters

Constituent	Ambient Water Quality Standard	Use
Alkalinity	20 mg/l as CaCO3 (or natural alkalinity, if less)	WWF, MF
Ammonia Nitrogen	Varies, per pH of water	WWF, MF
Fecal Coliform	5/1 to 9/30: 200 per 100 ml (geometric mean)	WC
	10/1 to 4/30: 2,000 per 100 ml (geometric mean)	WC
	Year Round: 5,000 per 100 ml (max monthly average)	PWS
	20,000 per 100 ml (<5% of samples)	
Chloride	250 mg/l	PWS
Color	75 units (platinum-cobalt scale)	PWS
Dissolved Oxygen	7-day average: 5.5 mg/l	WWF
	Minimum: 5.0 mg/l	WWF
Fluoride	Daily Average: 2.0 mg/l	PWS
Iron	30 day average: 2.0 mg/l	WWF, MF
Manganese	1.0 mg/l	PWS
Nitrite plus Nitrate	10 mg/l as nitrogen	PWS
Osmotic Pressure	50 milliosmoles/kg	WWF, MF
pH	Between 6.0 and 9.0	WWF, MF
Phenolics	0.005 mg/l	PWS
Sulfate	250 mg/l	PWS
Temperature	Varies throughout year	WWF
Total Dissolved Solids	Monthly Average: 500 mg/l	PWS
	Maximum: 750 mg/l	PWS
Total Residual Chlorine	4-day average: 0.011 mg/l	WWF, MF
	1-hour average: 0.019 mg/l	
Toxic Substances	Develop per Chapter 16	WWF, MF
Metals	Chronic, Acute Values	WWF, MF

The latest Integrated Report was issued by PaDEP in 2014 as a draft, with comments received at this writing. **Table 2** lists the attainment status of waters receiving discharges from CRW's combined sewers, according to the 2014 draft Integrated Report.

Table 2. Attainment Status of Waters Receiving Discharges from CRW's Combined Sewer System

Receiving Water	Designated Use	Cause / Constituent(s)	Source	Related to CSOs?	TMDL Date
Susquehanna	Fish Consumption	PCBs	Unknown	No	2027
	Potable Water	N/A	N/A	N/A	Attained
	Aquatic Life	N/A	N/A	N/A	Unassessed
	Recreation	N/A	N/A	N/A	Unassessed
Paxton Creek	Aquatic Life	DO/BOD	CSOs	Yes	None Required
		Siltation / TSS	Urban/Storm Sewers, Stream Erosion	Potential	2008
		Flow Variability	Urban / Storm Sewers	Potential	None Required
		Habitat Alteration	Urban / Storm Sewers	Potential	None Required
	Recreational	Pathogens	Unknown	Potential	2025

Paxton Creek TMDL

In 2008, the U.S. Environmental Protection Agency (EPA) established nutrient and sediment TMDLs for the Paxton Creek watershed. EPA's TMDL Report, *Nutrient and Sediment Total Maximum Daily Load in Paxton Creek Watershed, Pennsylvania*, assigns the sediment waste load allocation (WLA) to each jurisdiction proportionate to its U.S. Census Urbanized Area (2000). In a letter dated August 15, 2013, EPA withdrew the nutrient TMDL based on Pennsylvania's 2012 Integrated Report that revised the impairment status of Paxton Creek. The sediment TMDL remains, however, and assigns a sediment (total suspended solids) WLA to each MS4 in the watershed. The WLA requires a 35 percent reduction in the existing sediment waste load attributed to the MS4s. An erratum issued by EPA on August 28, 2013 reassigns the WLA to the correct MS4s, but does not change the WLA.

Sediment loads from CSOs were simulated as a CSO land use and estimated at 14.5 tons/year. The CSO area was taken proportionally from the model's high intensity land uses and adjusted until the total average CSO runoff volume matched the CSO volume projected from by the Harrisburg Authority's former 2005 Long Term Control Plan (LTCP) after implementation, 137 million gallons. The TMDL already accounts for the 15 percent (2.2 tons/year) TSS reduction projected under CRW's 2005 LTCP. CRW is currently re-projecting existing and projected future CSO volumes under its revised LTCP, which might affect the sediment loads / load reduction attributable to CSOs.

On October 1, 2014, CRW submitted the *Paxton Creek MS4 TMDL Strategy*, as part of its Individual MS4 permit application. It is envisioned that an integrated TMDL compliance plan that addresses the TMDL for CRW's MS4 and CSO systems may accompany development of the CSO LTCP.

Chesapeake Bay Watershed

The Chesapeake Bay TMDL established regulatory waste load allocations (WLAs) and load allocations (LAs) for nitrogen, phosphorus and total suspended solids (TSS) based in part on PA's Chesapeake Watershed Implementation Plan (WIP). Pennsylvania chose to sub-divide loads at the county-level, as the EPA Chesapeake Bay watershed model is based in part on county level data. The county planning targets address only those loads that can be reduced by Best Management Practices (BMPs). This includes both regulatory and non-regulatory loads for agriculture, stormwater and forest. The following load reductions are targeted for Dauphin County:

- Nitrogen: 1,465,368 lbs. (33 percent of estimated 2010 load)
- Phosphorus: 15,738 lbs. (30 percent of estimated 2010 load)
- Total Suspended Sediments: 15,394,886 lbs. (37 percent of estimated 2010 load)

Controls on urban runoff are targeted to achieve approximately 50 percent of the targeted nitrogen load reduction, approximately 40 percent of the targeted phosphorus load reduction, and approximately 70 percent of the targeted TSS load reduction. EPA's Chesapeake Bay Watershed Model also provides the BMP-level load reduction targets listed in **Table 3** as part of the Dauphin County Planning Targets. Interestingly, while the Paxton Creek TMDL concluded that the source of most TSS loads appears to be from streambank erosion, the BMPs considered for the Chesapeake Bay TMDL do not directly target streambank erosion.

The Dauphin County Planning Targets do not include instruction on how these load reduction targets are to be achieved within each jurisdiction, or provide specific guidance on how CRW's LTCP should factor into achieving these targets. CRW is required to provide a Chesapeake Bay Pollutant Reduction Plan under its Individual MS4 Permit, when issued. It is anticipated that the Dauphin County Planning Targets under the Chesapeake Bay TMDL will be considered in developing the CRW LTCP in conjunction with the Chesapeake Bay Pollutant Reduction Plan for CRW's MS4.

Review of Existing Water Quality Data

The water quality of the Susquehanna River and Paxton Creek has been actively monitored within the reaches receiving discharges from CRW's combined sewer system over the past decade or more. This section summarizes pertinent available data and published conclusions drawn from this data regarding CSO discharge characteristics, water quality, physical stream assessments, and biomonitoring for the Susquehanna River and Paxton Creek. An outline of identified data is presented in **Attachment A**.

Table 3. Pollutant Load Reduction Targets for Dauphin County

BMP	Units	2010	2017*	2025
Dry Detention Ponds/ Hydrodynamic Structures	Acres	21,187.4	9,718.4	2,072.3
Dry Extended Detention Ponds	Acres	3,765.9	2,749.7	2,072.3
Erosion and Sediment Control	Acres	535.3	923.1	1,181.6
Filtering Practices ***	Acres	0.0	15,459.1	25,765.2
Forest Buffers	Urban Acres	0.0	473.7	789.6
Grass Buffers	Urban Acres	0.0	283.0	471.7
Impervious Surface Reduction	Acres	0.0	91.3	152.2
Infiltration Practices ***	Acres	0.0	14,193.7	23,656.1
Septic System Hook-ups	Units	2,029.6	3,658.1	4,743.7
Street Sweeping	Acres	0.0	1,833.8	3,056.4
Tree Planting	Urban Acres	0.0	48.7	81.1
Urban Nutrient Management	Acres	0.0	10,512.2	17,520.3
Urban Sprawl Reduction	Acres	0.0	9.4	15.7
Urban Stream Restoration	Feet	0.0	1,684.5	2,807.4
Wet Ponds & Wetlands	Acres	3,169.8	6,241.4	8,289.2

NOTES:

Source: EPA's Chesapeake Bay Watershed Model

* 2017: 60% of 2025 BMPs.

*** Filtering Practices & *** Infiltration Practices: These BMPs were over projected in the 2025 WIP watershed model input deck to compensate for the EPA model's inability to address stormwater treatment trains.

Susquehanna River

The Susquehanna River's headwaters are located at Otsego Lake near Cooperstown, New York and the river passes through the City of Harrisburg before entering the Chesapeake Bay in Havre de Grace, Maryland. The Susquehanna River Basin drains 27,500-square miles of land comprising approximately half of Pennsylvania and portions of New York and Maryland. Harrisburg is located in the Lower Susquehanna River sub-basin.

CSO Monitoring

A flow monitoring program was developed as part of the 2005 LTCP to hydraulically characterize CRW's interceptor sewer system and estimate the overflow volume discharged to receiving water bodies. Activation times and discharge flows at select CSOs along the Susquehanna River were monitored between April and July 2003 to determine the total overflow volume during individual storm events as shown in **Figure 1**.

In addition to flow monitoring, samples were collected throughout overflow events to determine the combined sewer wastewater characteristics as outlined in **Table 4**. These values represent the event mean concentration (EMC) for each parameter and were used with overflow volume to estimate pollutant loads. These EMCs are consistent with values for CSO discharges as determined

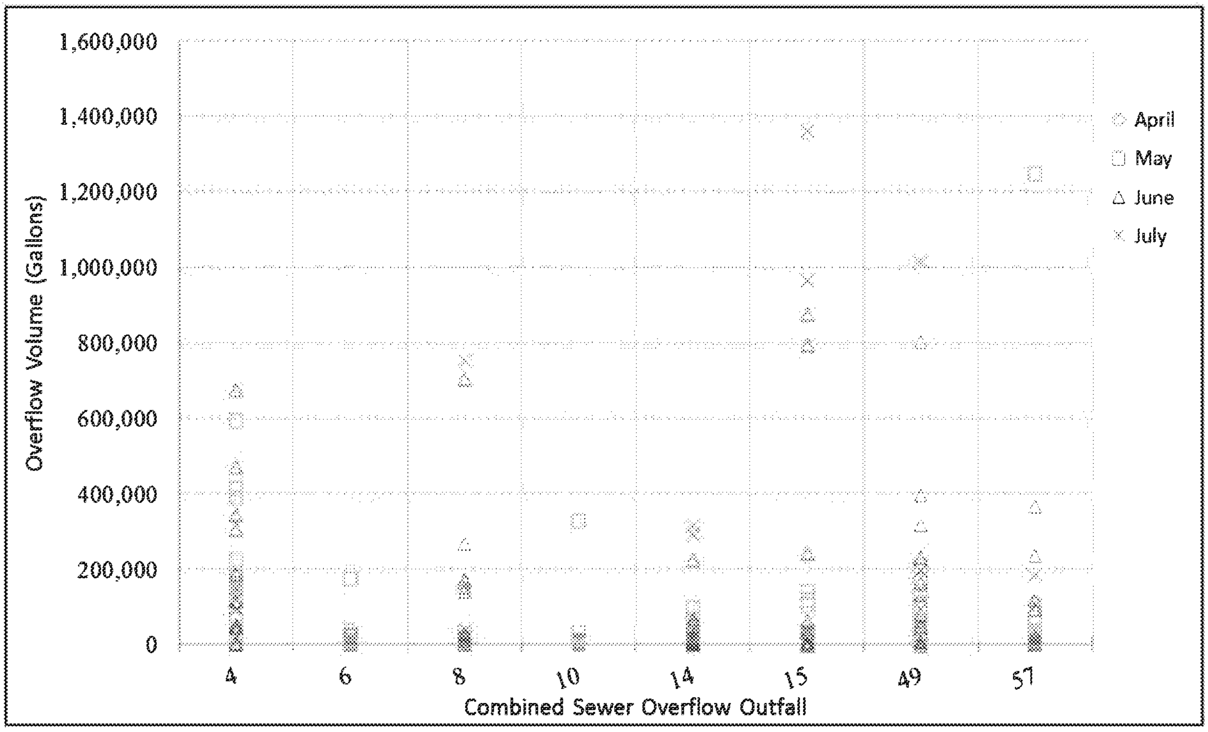


Figure 1. *Total Overflow Volume for Monitored CSOs on Susquehanna River Apr – Jul 2003.*

Table 4. *Event Mean Concentrations (EMCs) for Sampled CSOs Discharging to Susquehanna River.*

Sampling Location	Sampling Event	Σ Settleable Solids (mg/L)	TSS (mg/L)	BOD5 (mg/L)	Σ Nitrogen (mg/L)	Σ Phosphorus (mg/L)	Fecal Coliform (cfu/100mL)
CSO 04	6/3/2003	1.77	53.3	15.18	2.76	0.46	420,730
	10/14/2003	0.64	36.51	11.17	1.91	0.44	53,759
	11/19/2003	1	38.52	23.17	2.37	0.46	400,092
CSO 49	6/3/2003	1.33	59.48	56.7	3.92	0.59	387,512
	10/14/2003	-	-	-	-	-	-
	11/19/2003	-	-	-	-	-	-
CSO 06	6/3/2003	-	-	-	-	-	-
	10/14/2003	5.25	241.52	41.85	6.11	1.33	499,845
	11/19/2003	-	-	-	-	-	-
CSO 14	6/3/2003	0.86	54.94	60.06	5.53	0.85	386,968
	10/14/2003	8.32	374.97	34.99	6.95	1.39	272,818
	11/19/2003	0.23	50.17	19.56	1.94	0.33	135,322

for other systems. A comparison of the system-wide average EMC for each parameter compared to the Nation-wide Urban Runoff Program (NURP) recommended EMCs for annual loading calculations and published ranges is provided in **Table 5.** No additional CSO sampling is recommended since the 2005 LTCP data indicates that the pollutant concentrations of discharges from Harrisburg's sewer system are not statistically different than other similar systems, and since

Table 5. System-Wide Average Event Mean Concentrations (EMCs)

Parameter	System-Wide Average EMC (mg/L)	NURP-Recommended EMCs for Annual Loading Calculations (mg/L)	Published CSO EMC Ranges (mg/L)
Total Settable Solids	2.0	n/a	n/a
Total Suspended Solids	78.4	182.5	14 – 1021.3
BOD_5	24.8	11.5	7.8 – 262
Total Nitrogen	3.4	0.66 – 14.66	n/a
Total Phosphorus (as P)	0.61	0.42	0.0087 - 10.2
Fecal Coliform (#/100 mL)	230,466	21,000	500 - 120,000,000

few land use changes have occurred in Harrisburg over the past 10 years.

Water Quality Monitoring

The STORET database is EPA's primary repository of water quality data (http://www.epa.gov/storet/). Monitoring locations shown on **Figure 2** have relevant water quality data, including total dissolved solids, total suspended solids, nitrogen, phosphorus, and select metals. Generally, Water Quality Network (WQN) monitoring stations contain recent data after 2012, while other locations contain historical results dating as far back as 1984. **Attachment B** contains time series plots of select water quality monitoring data

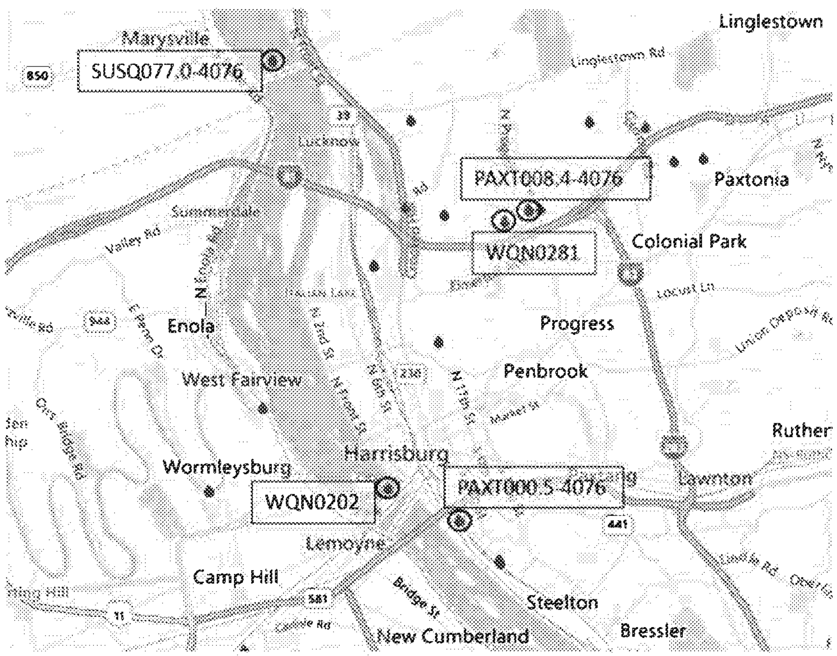


Figure 2. Water Quality Monitoring Stations from EPA STORET Database

contained in EPA STORET in the waters receiving discharges from CRW's sewer systems. When applicable, these results are compared to the ambient water quality standards in Table 1.

As part of the 2012 Susquehanna River Study, PaDEP performed sampling at three locations along the Susquehanna River at Harrisburg. Previous water quality sampling had documented variable water quality across transects of wide rivers. Therefore, one sample site was established 100 meters off the west shore, a second approximately 470 meters off the west shore near Wade Island, and a third 165 meters off the east shore. Dissolved oxygen, temperature, pH, and specific conductivity were monitored for a period between June and August 2012. Additionally, grab samples were taken at each location during monitoring events and analyzed for common chemical parameters. Results from this study indicated a significant difference in water quality from the east to west shore. This was attributed to the influence of the Juniata River which has a confluence on the west side of the Susquehanna River. Within the east transect, DO was significantly less variable and specific conductivity was elevated. Small DO variability suggests lower discharges of oxygen-demanding substances and/or higher aeration rates, resulting in few observed in-stream DO depletion events. Results from the 2012 Susquehanna River study are provided in **Attachment C**.

As part of 2005 LTCP, the Susquehanna River was sampled during three wet weather events in 2004 to determine the effect of CSO discharges on water quality. Fecal coliform, dissolved oxygen, pH, temperature, and turbidity were measured at various locations along the east and west transect of the river following wet-weather events. Results from this study indicated the formation of a fecal coliform plume in the River along the eastern shore adjacent to Harrisburg, and nearshore/offshore differences in dissolved oxygen concentrations supported this observation. Fecal coliform concentrations in the Susquehanna River following CSO discharges are outlined in **Attachment D**. Since background fecal coliform levels were determined to be low or non-detectable during dry-weather sampling, elevated fecal coliform levels during wet weather were attributed to CSO discharges. CSO discharges did not seem to have a significant impact on other parameters, however. Results from this sampling effort were used to calibrate and verify an in-stream water quality model which will be described subsequently in this memo.

Physical Assessment

The U.S. Geological Survey (USGS) maintains and operates station 01570500 in Harrisburg. This station is located on the east bank of City Island, 60 ft downstream from Market Street Bridge in Harrisburg, 3,670 ft upstream from sanitary dam, and 1.7 mi upstream from Paxton Creek. It has been in operation since 1890 and provides flow and supplemental water quality data. **Figure 3** presents historical flow data along the Susquehanna River at this station.

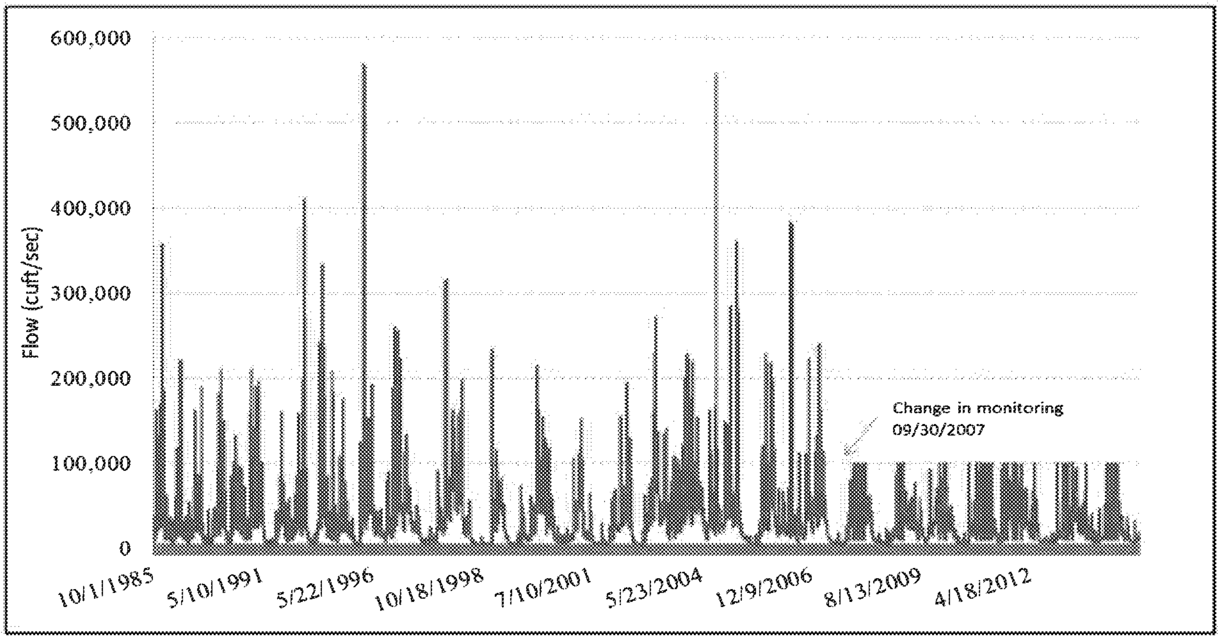


Figure 3. *USGS Flow Data at Station 01570500 on Susquehanna River.*

Biomonitoring

As part of the 2012 Susquehanna River Study, PaDEP performed sampling at three locations along the Susquehanna River in the water quality monitoring report as described under the water quality monitoring section above. As part of this assessment, macroinvertibrate testing was performed, and results from this analysis at the three locations along the Susquehanna River at Harrisburg are presented in **Table 6**. The benthic macroinvertibrate index of biological integrity for large wadeable riffle/run freestone streams (Large LBI) was used to quantitatively compare water quality conditions. The Susquehanna at Harrisburg West scored lowest when compared to the East and Middle sections. However, benthic macroinvertibrate data would suggest overall fair to good water quality conditions.

Table 6. *PADEP 2012-2013 Macroinvertibrate Metric and Index Results for Susquehanna River.*

Site Name	Large IBI Score	Richness	EPT Richness (PTV 0-4)	Hilsenhoff	Shannon Diversity	Mayfly Richness
Harrisburg West 2012	63.8	24	10	4.25	2.44	11
Harrisburg West 2013	59.3	17	9	4.14	2.33	8
Harrisburg Middle 2012	71.9	23	12	3.75	2.49	11
Harrisburg Middle 2013	62.5	19	9	4.03	2.24	9
Harrisburg East 2012	72.4	25	12	3.92	2.64	9
Harrisburg East 2013	60.3	18	6	3.84	2.01	8

Water Quality Modeling from CRW 2005 LTCP

A fecal coliform fate and transport model for a segment of the Susquehanna River was developed, calibrated, and verified as part of the 2005 LTCP. One of the main objectives for developing the model was to predict the spatial extent and duration of fecal coliform water quality violations in the Susquehanna River due to CRW CSO discharges under wet weather events and with various levels of control alternatives. Considering these objectives, a two-dimensional, depth-averaged model was required to simulate pollutant transport laterally across the river and downstream.

The Surface Water Modeling System (SMS) model package, developed by the Environmental Modeling Research Laboratory of Brigham Young University was chosen for this project. SMS is a pre- and post-processor graphical user interface for surface water modeling and analysis. Two numerical models included in the SMS system were used for this project. RMA2 is a hydrodynamic numerical model typically applied to simulate circulation in riverine and estuarine systems. RMA4 is designed to simulate the depth-average advection-diffusion process in aquatic environments and can be used to evaluate any conservative substance that is either dissolved or naturally buoyant within the water column. For this project, RMA4 used the hydrodynamic solution from RMA2.

The extent of the modeled area is bounded by the Dock Street Dam to the south and extends past the northern boundary of the City of Harrisburg between the Rockville Bridge and Marysville to the north. The model was segmented along this area with a two-dimensional model mesh as shown in **Figure 6**. Smaller segments were placed near CSO outfalls to more accurately model dispersion of fecal coliform plumes.

Baseline fecal coliform levels were determined to be low, if not non-detectable, based on dry weather sampling conducted in 2001 and 2002. Results from the three wet-weather sampling events in 2004 were used to calibrate and verify the model.

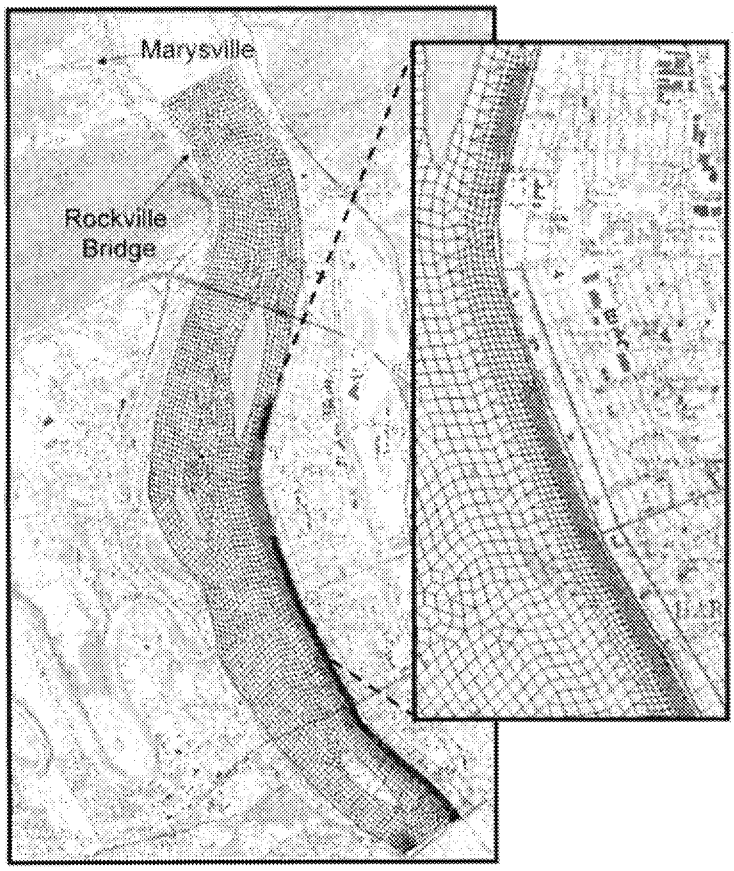


Figure 6. *Susquehanna River Fecal Coliform Model Area Segmentation.*

Paxton Creek

Paxton Creek is a 13.9-mile tributary of the Susquehanna River with a watershed that covers 27.4 square miles. Paxton Creek was dammed in 1908, forming Wildwood Lake just north of Harrisburg Area Community College. The southern outlet structure of Wildwood Lake, known as the "Morning Glory", is a circular structure designed to control water elevation. As the water level rises, discharge passes through the top opening, down a box culvert, and out a riser pipe and splash apron. Due to this outlet configuration, Wildwood Lake acts as a depository for sediment and other pollutants discharged to Paxton Creek upstream of the City of Harrisburg and CRW's combined sewer system. Therefore, the characteristics upstream and downstream of Wildwood Lake may vary significantly.

CSO Monitoring

Similar to CSO monitoring for locations along the Susquehanna River, select CSO outfalls discharging into Paxton Creek were monitored as part of the 2005 LTCP flow monitoring program. The total overflow volume at these locations is presented in **Figure 4**. Sampling during CSO discharges was used to determine the combined sewer wastewater characteristics as outlined in **Table 7**. These values represent the event mean concentration (EMC) for each parameter. These EMCs are consistent with values for CSO discharges as determined for other systems as shown in **Table 5** above.

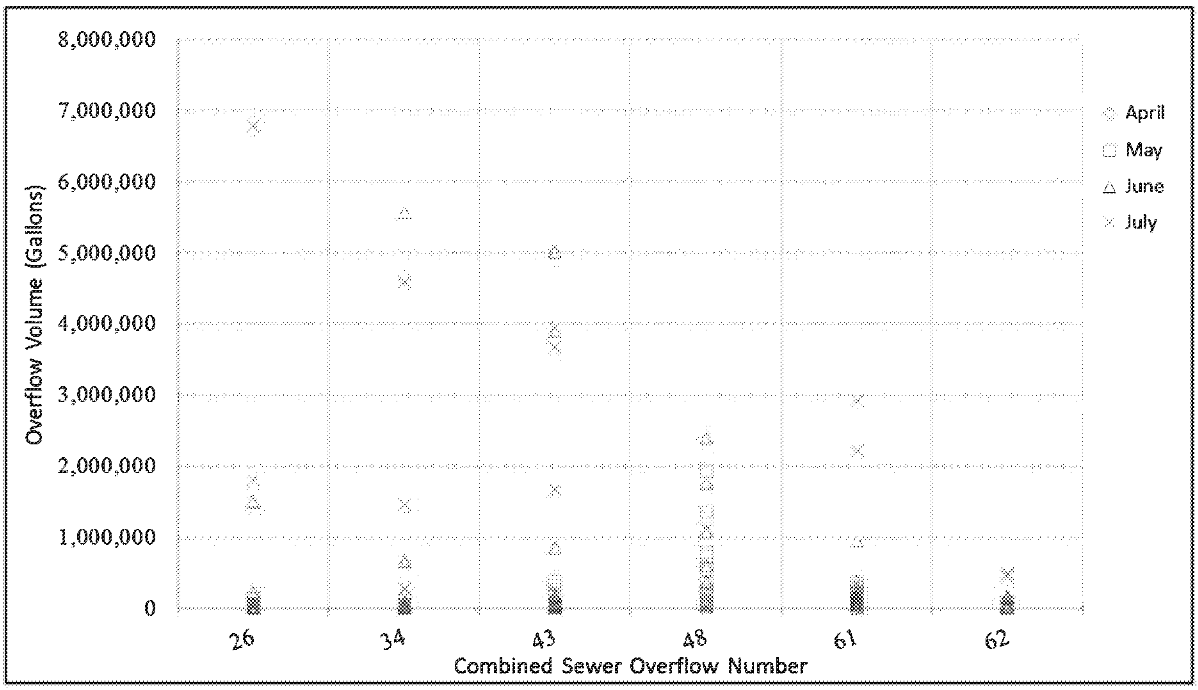


Figure 4. Total Overflow Volume for Monitored CSOs on Paxton Creek Apr – Jul 2003.

Table 7. Event Mean Concentrations (EMCs) for Sampled CSOs Discharging to Paxton Creek.

Sampling Location	Sampling Event	Σ Settleable Solids (mg/L)	TSS (mg/L)	BOD5 (mg/L)	Σ Nitrogen (mg/L)	Σ Phosphorus (mg/L)	Fecal Coliform (cfu/100mL)
CSO 31	6/3/2003	-	-	-	-	-	-
	10/14/2003	-	-	-	-	-	-
	11/19/2003	2.75	63.33	22.96	2.58	0.45	158,729
CSO 43	6/3/2003	2.87	155.96	104.04	13.47	2.52	1,424,943
	10/14/2003	2.14	72.21	31.38	2.91	0.43	225,195
	11/19/2003	-	-	-	-	-	-
CSO 48	6/3/2003	0.69	105.71	23.01	4.46	0.84	981,414
	10/14/2003	2.2	130.84	45.26	5.19	0.83	144,349
	11/19/2003	-	-	-	-	-	-
CSO 62	6/3/2003	0.36	103.1	4.11	1.68	0.19	117,346
	10/14/2003	2.13	95.68	6.92	1.46	0.2	19,538
	11/19/2003	2.74	50.62	10.72	1.88	0.15	4,324

Water Quality Monitoring

EPA STORET contains water quality results for locations along Paxton Creek as identified in **Figure 2. Attachment B** contains time series plots of select water quality monitoring data at these locations. The effects of CSO discharges are limited to the lower section of Paxton Creek main stem. When applicable, these results are compared to the ambient water quality standards in **Table 1**.

Findings of the PaDEP's Ambient Water Quality Monitoring under Dry Weather for the Paxton Creek Watershed are found in Section 3.1.1 of the 2008 TMDL Report. The major conclusions from this assessment, which was conducted in 2004 and 2006, are below.

- Alkalinity, DO, pH, sulfate, manganese, and iron levels were in compliance with the established state criteria.
- TDS concentrations collected on March 17, 2004 exceeded the maximum criteria of 700 mg/L five times (range: 6 and 1018 mg/L). The majority of all exceedances recorded within the watershed were observed in tributary streams, not the main stem of Paxton Creek, and do not appear to be related to CSO discharges.
- Specific conductivity was higher in the middle and lower section of Paxton Creek (range: 387 to 1199 µMhos/cm) than in the headwaters (range: 93 to 453 µMhos/cm).
- TSS concentrations generally ranged between 1 and 26 mg/L at stations located along both Paxton Creek and its tributaries. However, higher TSS concentrations were noted at two stations, including station PC02 (225 mg/L), downstream of confluence with Asylum Run and potentially influenced by CRW's CSOs.
- Hardness concentrations measured within the watershed were on average 150 mg/L. The lowest hardness concentrations were recorded at the upstream stations of Paxton Creek.

- Carbonaceous BOD_5 and BOD_{20} were on average 1.79 and 1.64 mg/L.
- TN concentrations measured within the watershed ranged between 0.77 and 4.15 mg/L. TN concentrations at stations on the mainstem of Paxton Creek were on average 1.32 mg/L and increased slightly downstream.
- TP concentrations measured within the watershed ranged between 0.011 and 0.064 mg/L. TP concentrations at stations on the mainstem of Paxton Creek were on average 0.032 mg/L and increased slightly downstream.
- Bacteria concentrations ranged between 100 and 11,000 col/100ml for total coliform, 4 to 1,500 col/100ml for fecal coliform, and 10 to 810 col/100ml for fecal streptococcus. The highest bacterial levels were recorded in the downstream section of Paxton Creek at stations PC02 and PC03, at the confluence of Paxton Creek with the Susquehanna River. Based on the majority of samples, bacteria levels recorded at tributary stations were lower than those along the mainstem.

Findings of the PaDEP's Ambient Water Quality Monitoring under Wet Weather for the Paxton Creek Watershed are found in Section 3.1.4 of the 2008 TMDL Report. The major conclusions from this assessment, which was conducted in September 2006, are below.

- DO sags occurred near CSOs (at PC02 and PC03). Because of the abrupt decrease and recovery of DO in the stream, the DO sag was likely triggered by DO-depleted water delivered by the CSOs located in the downstream section of Paxton Creek.
- In total, nutrient, CBOD and sediment concentrations increased significantly under wet weather conditions.
- In particular, biochemical oxygen demand was substantially high.
- Total phosphorus and total nitrogen were approximately fourteen and five times higher than measurement collected prior to the rainstorm. The majority of the nutrients were found in organic forms.

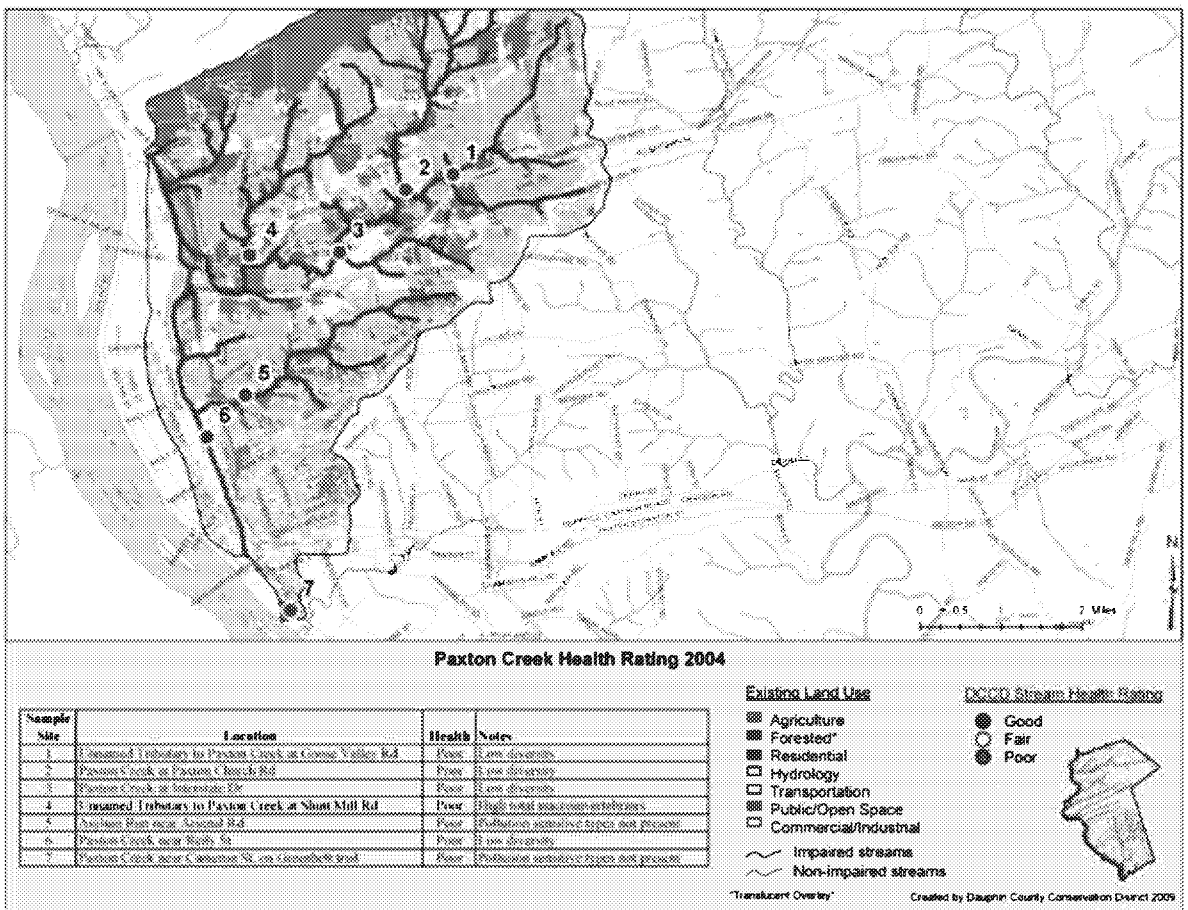
Physical Assessment

Findings of the Susquehanna River Basin Commission (SRBC) Habitat Condition Assessment are found in Section 3.2.2 of the Paxton Creek 2008 TMDL Report. Habitat parameters that were examined include epifaunal substrate, embeddedness, velocity, sedimentation, channel flow, channel alteration, frequency of riffles, bank stability, vegetation protection, and riparian zone. During each sample event, parameters were assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions. The score from each habitat parameter is totaled for a maximum score of 200.

Overall, habitat assessment scores from fall of 2006 and spring 2007 were consistently low at the two monitoring stations in Paxton Creek downstream of Wildwood Lake with total scores ranging between 66 and 91 with an average score of 76 of 200. Scores for habitat metrics such as epifaunal substrate, embeddedness, sediment deposition, and bank stability, were consistently low at monitoring stations along the sediment-impaired segments of Paxton Creek, including the two locations downstream of Wildwood Lake. The monitoring location downstream of CRW CSOs received the lowest overall habitat scores from this study. Much of this portion of Paxton Creek is concrete lined, a physical alteration that affects habitat quality. Results from SRBC's Habitat Condition Assessment of Paxton Creek are included in **Attachment E**.

Biomonitoring

Macroinvertibrate testing was performed in 2004 by the Dauphin County Conservation District (DCCD) as part of the Countywide Stream Assessment Program (CSAP). Results from this assessment were used to rate the overall health of the stream, as indicated in **Figure 5**.



Sample Site	Location	Health	Notes
1	Unnamed Tributary to Paxton Creek at Goose Valley Rd	Poor	Low diversity
2	Paxton Creek at Paxton Church Rd	Poor	Low diversity
3	Paxton Creek at Interstate Dr	Poor	Low diversity
4	Unnamed Tributary to Paxton Creek at Shutt Mill Rd	Poor	High total macroinvertebrates
5	Asylum Run near Arsenal Rd	Poor	Pollution sensitive types not present
6	Paxton Creek near Reily St	Poor	Low diversity
7	Paxton Creek near Cameron St. on Greenbelt trail	Poor	Pollution sensitive types not present

Figure 5. DCCD 2004 Health Assessment for Paxton Creek.

All sites had few sensitive species and samples were dominated by pollution tolerant midges and aquatic worms. Poor aquatic habitat was also noted throughout the watershed. Sediment from eroded banks was prevalent. All sites within Paxton Creek were rated poor based on this assessment. Metrics and results used for this determination are provided in **Table 8**.

Table 8. DCCD 2004 Biomonitoring Metrics for Paxton Creek

	HBI		Total Taxa		Becks Index		Shannon Div		% PTV <4		EPT taxa (0-4)	
Report Name	OB	SV=(10-OB) / (10-1.89)	OB	SV=OB / 33	OB	SV=OB / 38	OB	SV=OB / 2.86	OB	SV=OB / 84.5%	OB	SV
1	5.19	0.59	8	0.24	47	1.24	0.74	0.26	2.4%	0.028	3	0.158
2	5.77	0.52	11	0.33	4	0.11	0.98	0.35	4.3%	0.051	3	0.158
3	6.21	0.47	12	0.36	1	0.03	1.15	0.40	2.8%	0.033	3	0.158
4	4.93	0.63	23	0.70	7	0.18	2.33	0.81	9.0%	0.107	8	0.421
5	6.08	0.48	8	0.24	0	0.00	0.88	0.31	0.0%	0.000	0	0.000
6	6.86	0.39	14	0.42	2	0.05	1.78	0.62	1.4%	0.017	3	0.158
7	9.42	0.07	7	0.21	0	0.00	0.63	0.22	0.0%	0.000	0	0.000

		Adjusted Standardized Metric Score (max:1.00)						
Report Name	Site Name	HBI	Total Taxa	Becks	Shannon	% PTV	EPT taxa	IBI
1	UNTP 10.71	0.59	0.24	1.00	0.26	0.028	0.158	38.01
2	PXTN 09.91	0.52	0.33	0.11	0.35	0.051	0.158	25.25
3	PXTN 08.41	0.47	0.36	0.03	0.40	0.033	0.158	24.17
4	UNTP 00.14	0.63	0.70	0.18	0.81	0.107	0.421	47.48
5	ASYL 00.76	0.48	0.24	0.00	0.31	0.000	0.000	17.22
6	PXTN 02.76	0.39	0.42	0.05	0.62	0.017	0.158	27.68
7	PXTN 00.20	0.07	0.21	0.00	0.22	0.000	0.000	8.40

Findings from the Susquehanna River Basin Commission (SRBC) macroinvertibrate testing in 2004 and 2006 are presented in Section 3.2.2 of the Paxton Creek 2008 TMDL Report. Samples were taken at various locations throughout the Paxton Creek watershed, and results were compared between the unimpaired and sediment.-impaired sections as outlined below. The monitoring location downstream of CRW CSOs is included under the sediment-impaired classification. Data from this analysis is provided in **Attachment F.**

- High numbers of macroinvertibrate were measured within the unimpaired segments (on average 1237) and low numbers (on average 468) of macroinvertibrates within the sediment-impaired segments.
- High numbers of sensitive macroinvertibrate (Ephemeroptera, Plecoptera, and Trichoptera) were collected in the unimpaired segments (138) and low numbers in the sediment-impaired segments.

Pollutants of Concern

Table 9 identifies the pollutants of concern for the Susquehanna River and Paxton Creek associated with CSOs, identified based on the various water quality / stream attainability studies by PaDEP and others, and from prior available water quality monitoring and modeling information:

Sediment

- The 2008 Paxton Creek TMDL Report indicates that sediment is the primary pollutant of concern in Paxton Creek, with about 95 percent attributed to stream erosion and the rest to wet weather discharges.
- Total suspended sediment has not been identified as a pollutant of concern in the Susquehanna River.

Table 9. Pollutants of Concern Discharging from CRW's Combined Sewer System

Pollutant of Concern	Susquehanna River	Paxton Creek	Chesapeake Bay
Sediment		💧	💧
Bacteria	💧	💧	
Dissolved Oxygen / BOD		💧	
Nitrogen / Phosphorus			💧

Bacteria

- Bacteria is a pollutant of concern in both receiving water bodies due to human health risks from pathogens during in-stream recreational activities. Paxton Creek is not in attainment for recreational uses due to elevated bacteria levels. The Susquehanna is currently in attainment for recreational uses, however elevated levels of bacteria are associates with CSOs and present a potential threat in areas of the Susquehanna used for recreation.

Oxygen Demanding Constituents

- The 2008 TMDL Report for Paxton Creek reported significant DO sags due to discharges from the combined sewer system.
- Oxygen-demanding substances (e.g., BOD, COD) that cause dissolved oxygen concentrations to fall below limits necessary to sustain aquatic life should be considered a pollutant of concern in Paxton Creek.
- Dissolved oxygen concentrations along the east transect of the Susquehanna appear stable.

Nutrients

- Nitrogen and phosphorus loads must be reduced under the Pennsylvania Chesapeake Watershed Implementation Plan, and thus should be considered pollutants of concern for CSOs to both receiving water bodies.
- Existing levels of wet weather treatment achieved by CRW's combined sewer system, coupled with additional treatment achieved under the LTCP, will help achieve the targeted nitrogen load reduction of approximately 50 percent and the targeted phosphorus load reduction of approximately 40 percent.

LTCP Development Approach

According to the *CSO Guidance for Long-Term Control Plan* (USEPA, 1995), "*the demonstration and presumption approaches provide municipalities with targets for CSO controls that achieve compliance with the Clean Water Act, particularly protection of designated uses*". Section 3.2 of the Guidance suggests criteria for determining if the demonstration or presumption approach are more appropriate for a particular situation, including the following:

- ***Criteria:*** *"Characterization will enable the NPDES permitting authority .... to determine whether the demonstration or presumption approach is the most suitable".*

  Assessment for CRW: Characterization of waters receiving CRW's CSOs is presented in this memo, however characterization of the combined sewer system and the CSOs from this system is ongoing, scheduled to be completed by April 2016.

- ***Criteria:*** *"Generally, if sufficient data are available to demonstrate that the proposed plan would result in an appropriate level of CSO control, then the demonstration approach will be selected".*

  Assessment for CRW: The information presented in this memorandum on the current level of attainment of beneficial uses in the Susquehanna River and Paxton Creek, the relatively extensive level of supporting water quality data and modeling, the TMDL for Paxton Creek, and the Pennsylvania Chesapeake Watershed Implementation Plan, is not considered sufficient to demonstrate CSO control levels.

- ***Criteria:*** *"The demonstration approach is particularly appropriate where attainment of WQS cannot be achieved through CSO control alone, due to the impacts of non-CSO sources of pollution".*

  Assessment for CRW: Non-CSO sources do not affect attainment for bacteria, the pollutant of concern for the Susquehanna, or DO/BOD, a pollutant of concern for Paxton Creek.

- ***Criteria:*** *"In cases where the natural background conditions, or pollution sources other than CSOs, are contributing to exceedances of WQS, the State is responsible for the development of a TMDL and the WLA for any CSOs. The municipality must then demonstrate compliance with the effluent limitation derived from the WLA established as part of the TMDL."*

  Assessment for CRW: The State / EPA has already developed TMDLs for Paxton Creek and Chesapeake Bay and established the necessary load reduction targets.

- ***Criteria:*** *"Use of the presumption approach is contingent, however, on the municipality presenting sufficient data to the NPDES permitting authority to allow the agency to make a reasonable judgment that WQS will probably be met with a control plan that meets one of the three presumption criteria."*

Assessment for CRW: The following section provides a demonstration that a LTCP developed under the presumption approach will probably meet WQS.

- ***Criteria:*** *"The choice between the demonstration approach and presumption approach does not necessarily have to be made before a municipality commences work on its LTCP."*

  Assessment for CRW: Since adequate water quality data exists to characterize each receiving water, and necessary load reductions have already been determined for most POCs, no additional water quality data is required and the final section of the LTCP approach can be deferred until the hydraulic model of the combined sewer system is complete. Selection of the appropriate compliance approach may be re-evaluated at this time, or while evaluating the cost-effectiveness of a range of presumptive control levels, as envisioned under the partical Consent Decree.

- ***Criteria:*** The CSO Control Policy recognizes that "*. . . data and modeling of wet weather events often do not give a clear picture of the level of CSO controls necessary to protect WQS*"

  Assessment for CRW: *Agreed.*

- ***Criteria:*** *"The intent of the minimum level of treatment recommended in the presumption approach is to control floatables, pathogens, and solids."*

  Assessment for CRW: Agreed, and further justification that the presumption approach is appropriate for determining control levels for most pollutants of concern.

- ***Criteria:*** *"At the discretion of the NPDES permitting authority, municipalities with populations of less than 75,000 need not be required to complete each of the formal steps outlined in the CSO Control Policy."*

  Assessment for CRW: The population served by CRW's combined sewer system is much smaller than the threshold population of 75,000 triggering small system considerations. As such, CRW suggests that expenditure of its limited resources on additional water quality monitoring and modeling would yield little additional understanding of WQS attainment, and that the presumptive approach is the most cost-effective approach for LTCP development.

Further conclusions and recommendations on the appropriate LTCP compliance approach for each receiving water follows.

Susquehanna River

The Susquehanna River is currently in attainment for all constituents except PCBs (not related to CSOs) and bacteria. The following conclusions may be drawn from available Susquehanna River monitoring observations and modeling results:

- No significant upstream sources of bacteria affect water quality along the eastern shore of the Susquehanna River.

- The fecal coliform plume generated by CRW CSOs remains in the nearshore portion of the river adjacent to the City of Harrisburg and persists in the near-shore area for only a few hours following a CSO event.

- Pennsylvania Code Chapter 96 requires water quality standards to be met 99 percent of the time when establishing a water quality based effluent limitation (WQBEL) or TMDL. This implies that excursions from water quality standards up to 1 percent of the time are allowed. In other words, excursions of water quality standards are allowed up to a total of 3.65 days (87.6 hours) over a typical year.

- Under the presumptive standard, CSO discharges would be reduced in volume, duration, and/or frequency. Since available water quality data and previous water quality modeling indicated that water quality excursions during a CSO event persist for only a few hours, it is reasonable to assume that the presumptive criteria would "probably meet" water quality standards.

Paxton Creek

Paxton Creek in the vicinity of CRW's CSOs is not in attainment for DO/BOD (attributed to CSO discharges) and sediment (attributed primarily to stream erosion). The following conclusions may be drawn from available Paxton Creek water quality observations and analyses:

- Extrapolation of the conclusions drawn for the Susquehanna River indicate that meeting the presumptive criteria would "probably meet" WQS for bacteria in Paxton Creek as well.

- PaDEP's Ambient Water Quality Monitoring concluded that an abrupt decrease and recovery of in-stream DO during wet weather is triggered by DO-depleted water delivered by CSOs. Achieving the presumption criteria (e.g., 4 CSOs per year), coupled with the observed rapid recovery of DO, would "probably meet" WQS 99 percent of the time. DEP's draft 2014 Integrated Report (Section 305b/303d) states that CRWs LTCP will result in attainment of WQS for DO/BOD.

- Compliance with the sediment load reduction targets in the Paxton Creek TMDL can be demonstrated with the hydraulic model of CRW's combined sewer system at various levels of CSO reduction and EMC's derived through previous sampling.

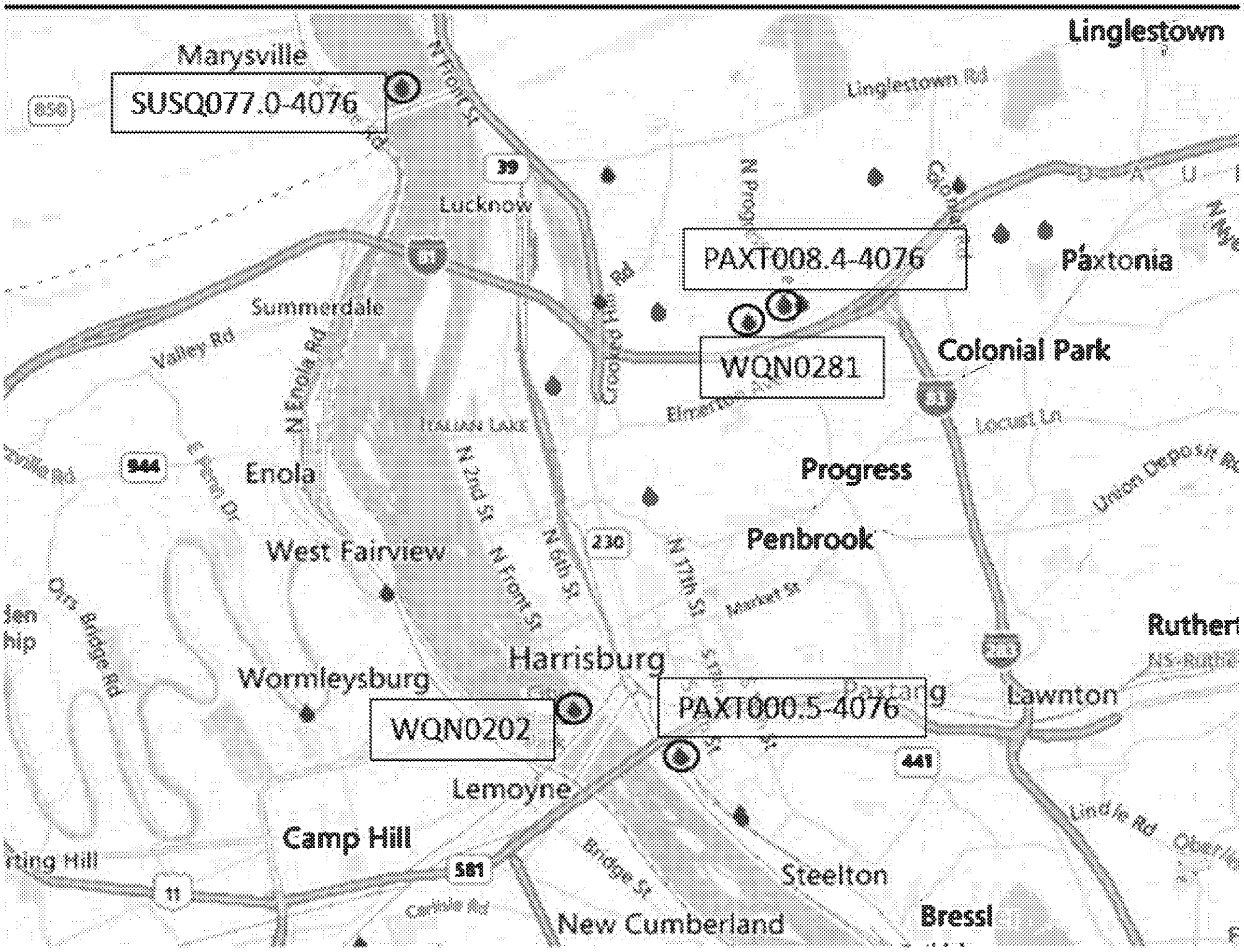
- CSO reductions will reduce the duration of erosive flows / velocities in Paxton Creek. While the portion of Paxton Creek receiving CSOs is largely concrete lined and able to withstand higher velocities, it presents physical alterations that may prevent compliance with WQs.

- On October 1, 2014, CRW submitted the *Paxton Creek MS4 TMDL Strategy*, as part of its Individual MS4 permit application. It is envisioned that compliance with the TMDL for CRW's MS4 and CSO systems will be coordinated as the CSO LTCP is prepared.

Chesapeake Bay

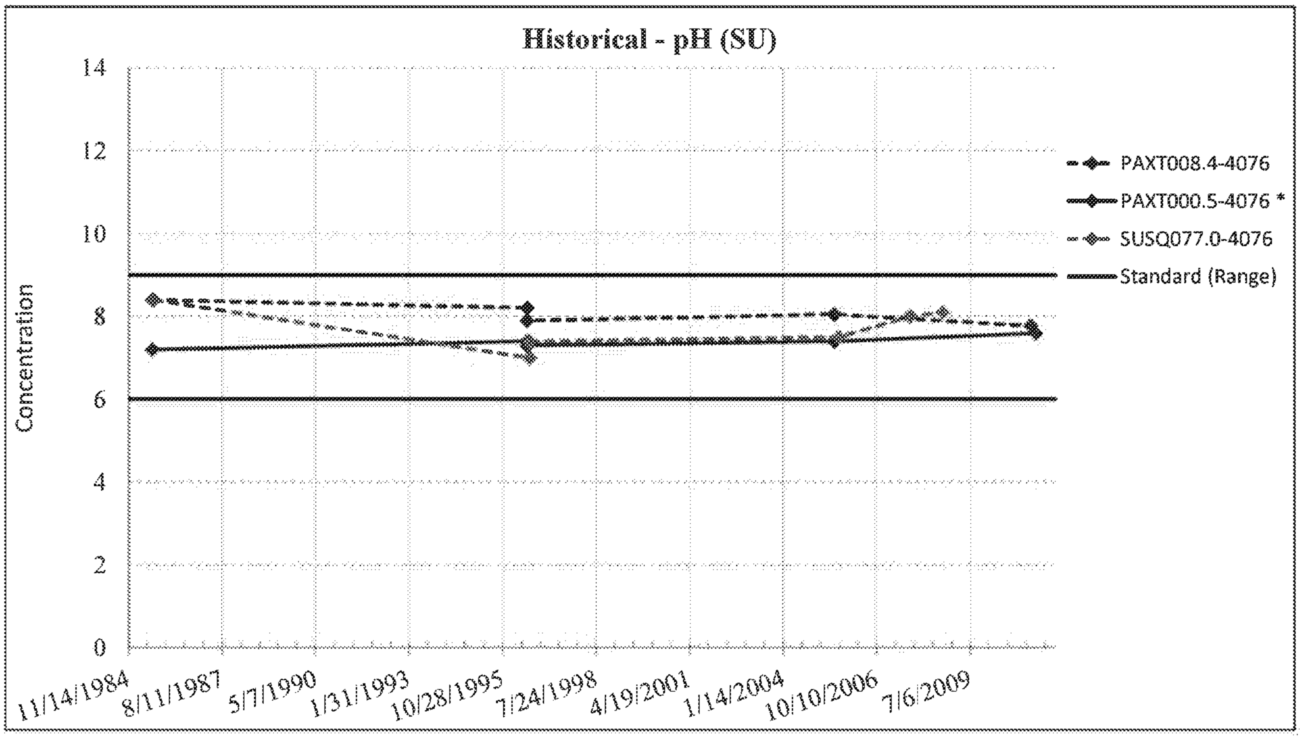
Assessment of nitrogen and phosphorus load reductions under the Pennsylvania Chesapeake Watershed Implementation Plan can be determined using the hydraulic model of CRW's combined sewer system, which will define CSO volumes and, using EMC's derived through previous sampling, determine the load reduction achieved at various levels of CSO reduction.

Source	Section	Sampling Type	Dates	Locations	Parameters
2005 LTCP	Appendix E	Rainfall Monitoring		2 Locations; John Harris School and Harrisburg AWTF	Event Start, Duration, Accumulation, Return Frequency
2005 LTCP	Appendix E	Flow Monitoring (In-System)		15 Locations	Flow
2005 LTCP	Appendix E	CSO Activation	Nov 2001 - June 2002	CSO 14, 26, 49, 62	Activation, Duration, Overflow Volume (calculated from water level)
2005 LTCP	Appendix E	CSO Activation	Apr 2002 - July 2003	CSO 04, 06, 08, 10, 14, 15, 26, 31, 34, 43, 48, 49, 57, 61, 62	Activation, Duration, Overflow Volume (calculated from water level)
2005 LTCP	Appendix H	CSO Sampling	June, Oct, Nov 2003	CSO 04, 06, 14, 31, 43, 48, 49, 62	Total Settleable Solids, TSS, BOD5, Total Nitrogen, Total Phosphorus, Fecal Coliform, DO (field), pH (field), and Temperature
2005 LTCP	Appendix J	Drogue (Flow Path)	June 2004	CSO 04, 10	
2005 LTCP	Appendix J	General Testing	July, Sept, Nov 2004	Susquehanna River (east and west transect)	Fecal Coliform, DO, Turbidity, Temperature, and pH
2008 TMDL	USGS Results	Ambient Water Quality	2006	Paxton Creek	Temperature, DO, Conductivity, pH
2008 TMDL	PADEP Results	Ambient Water Quality	2004, 2006	Paxton Creek	Nitrogen, Phosphorus, BOD, Nitrate, Ammonia, Phosphate, Total Organic Carbon, Dissolved Organic Carbon, Total Suspened Solids, Total Dissolved Solids, Alkalinity
2008 TMDL	SRBC Results	Ambient Water Quality	2006, 2007	Paxton Creek	Temperature, Conductivity, DO, pH, Turbidity, Habitat Score
2008 TMDL	SRBC Results	Habitat Testing	2006, 2007	Paxton Creek	Epifunal Substrate/Available Cover, Embeddedness, Velocity/Depth Regime, Sediment Deposition, Channel Flow Status, Channel Alteration, Frequency of Riffles, Bank Stability, Vegetative Protection, Riprarian Vegetative Zone Width, Total Score
2008 TMDL	SRBC Results	Biological Testing	2006, 2007	Paxton Creek	70 Genus (approximate)
EPA STORET Data	Regular Results	General Testing	2012 - 2013	All; WQN0202 (Susquehanna), WQN0281 (Paxton), WQN0283 (Spring)	Alkalinity, Aluminum, Ammonia, Barium, Boron, Bromide, Calcium, Chloride, Copper, DO, Flow, Hardness, Iron, Lead, Magnesium, Manganese, Nickel, Nitrate, Nitrite, Nitrogen, Carbon, Orthophosphate, Osmotic Pressure, pH, Phosphorus, Potassium, Selenium, Sodium, Conductivity, Strontium, Sulfate, Suspended Sediment Concentration, Temperature, Total Dissolved Solids, Total Suspended Solids, Zinc
EPA STORET Data	Regular Results	General Testing	1985, 1996, 2005, 2007, 2008, 2011 (inconsistent)	All; PAXT000.5-4076, PAXT008.4-4076, SUSQ077.0-4076, SPRG000.4-4076	Acidity, Alkalinity, Aluminum, Ammonia, BOD, Calcium, Chloride, DO, Flow, Fluoride, Hardness, Iron, TKN, Lead, Magnesium, Manganese, Nitrate, Nitrite, Nitrogen, Organic Carbon, Orthophosphate, pH, Phosphorus, Sodium, Conductivity, Sulfate, Temperature, Total Dissolved Solids, Total Suspeneded Solids, Turbidity, Zinc
EPA STORET Data	Biological Results	Biological Testing	1985, 1996, 2005, 2007, 2008, 2011 (inconsistent)	All; PAXT000.5-4076, PAXT008.4-4076, SUSQ077.0-4076, SPRG000.4-4076	67 Taxons
PADEP Susquehanna River Study	2012	Ambient Water Quality	June 2012 - Aug 2012	Susquehanna River (Harrisburg East, Middle, West)	Temperature, Conductivity, pH, DO
PADEP Susquehanna River Study	2012	Chemical Testing	July 2012 - Aug 2012	Susquehanna River (Harrisburg East)	Ammonia, Nitrogen (total and dissolved), Nitrate (total and dissolved), Phosphorus (total and dissolved), Total Suspended Solids
PADEP Susquehanna River Study	2012	Biological Testing	Aug 2012	Susquehanna River (Harrisburg East, Middle, West)	Benthic Macroinvertebrates
PADEP Susquehanna River Study	2012 - 2013	General Testing	2012 - 2013	Susquehanna River	Benthic Macroinvertebrates, Fish, Mussels, Algae, Continuous Instream (summer), Passive Samplers, Water Chemistry, Herbicide/Pesticide, Sediment
USGS Data	USGS Results	Flow Monitoring	1984 - Present	Susquehanna River; Station 01571000 near Penbrook	Flow



Station ID	State	County	HUC	Station Latitude	Station Longitude	Location
PAXT008.4-4076	PENNSYLVANIA	DAUPHIN	2050305	40.3080556	-76.85	Paxton Creek (upstream at N. Progress)
WQN0281	PENNSYLVANIA	DAUPHIN	2050305	40.3058	-76.8556	Paxton Creek (upstream of Wildwood)
* PAXT000.5-4076	PENNSYLVANIA	DAUPHIN	2050305	40.2502778	-76.8669444	Paxton Creek (at Sycamore)
SUSQ077.0-4076	PENNSYLVANIA	DAUPHIN	2050305	40.3358333	-76.9125	Susquehanna (upstream at Marysville)
* WQN0202	PENNSYLVANIA	DAUPHIN	2050305	40.2564	-76.8844	Susquehanna (at City Island)

* Denotes monitoring locations downstream of Capital Region Water's Combined Sewer System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10
8
6
4
2
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8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
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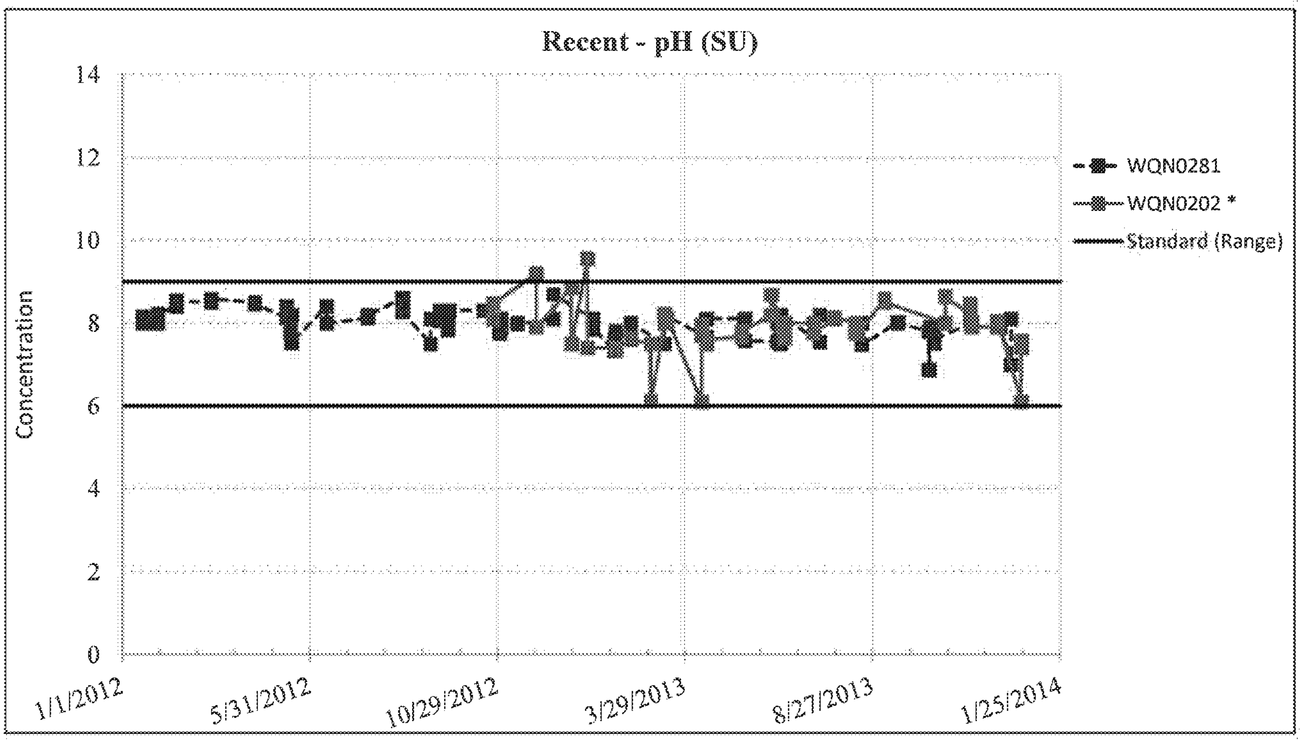
SUSQ077.0-4076
Standard (Range)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8
6
4
2
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Concentration
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1/25/2014
WQN0281
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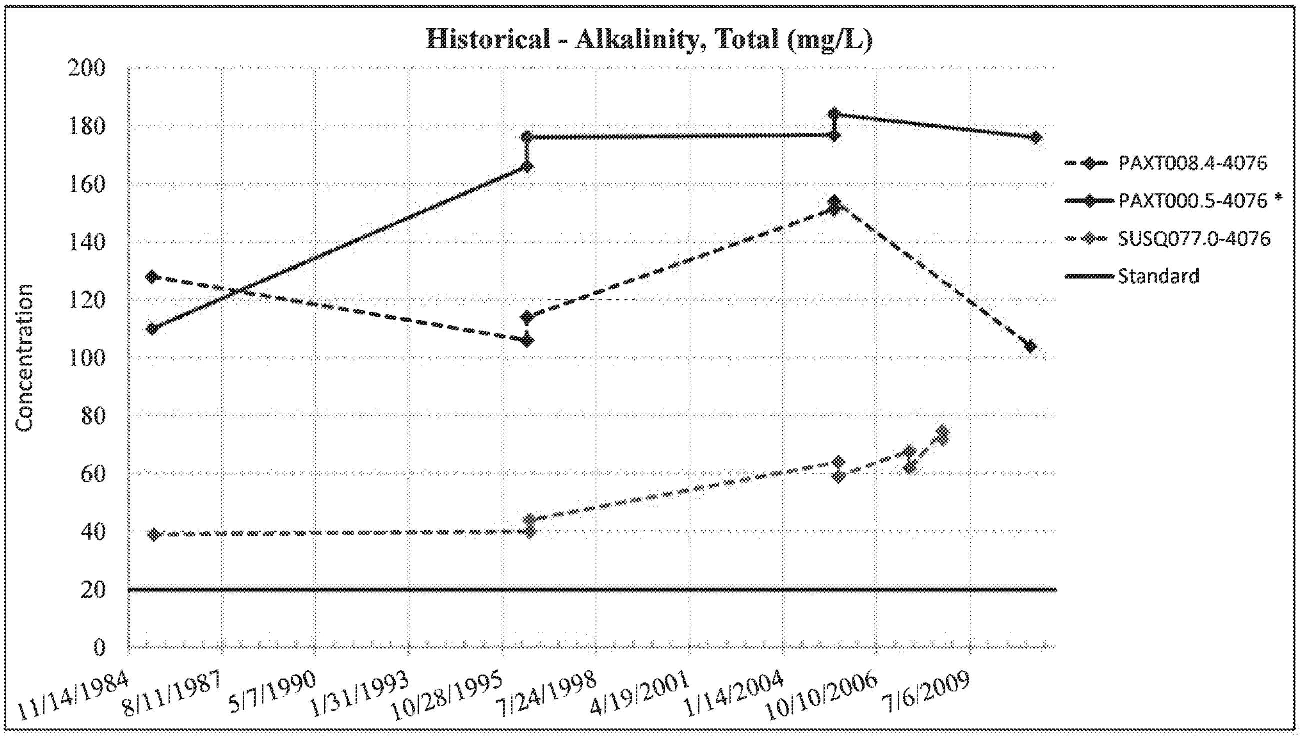
Standard (Range)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60
40
20
0
Concentration
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5/7/1990
1/31/1993
10/28/1995
7/24/1998
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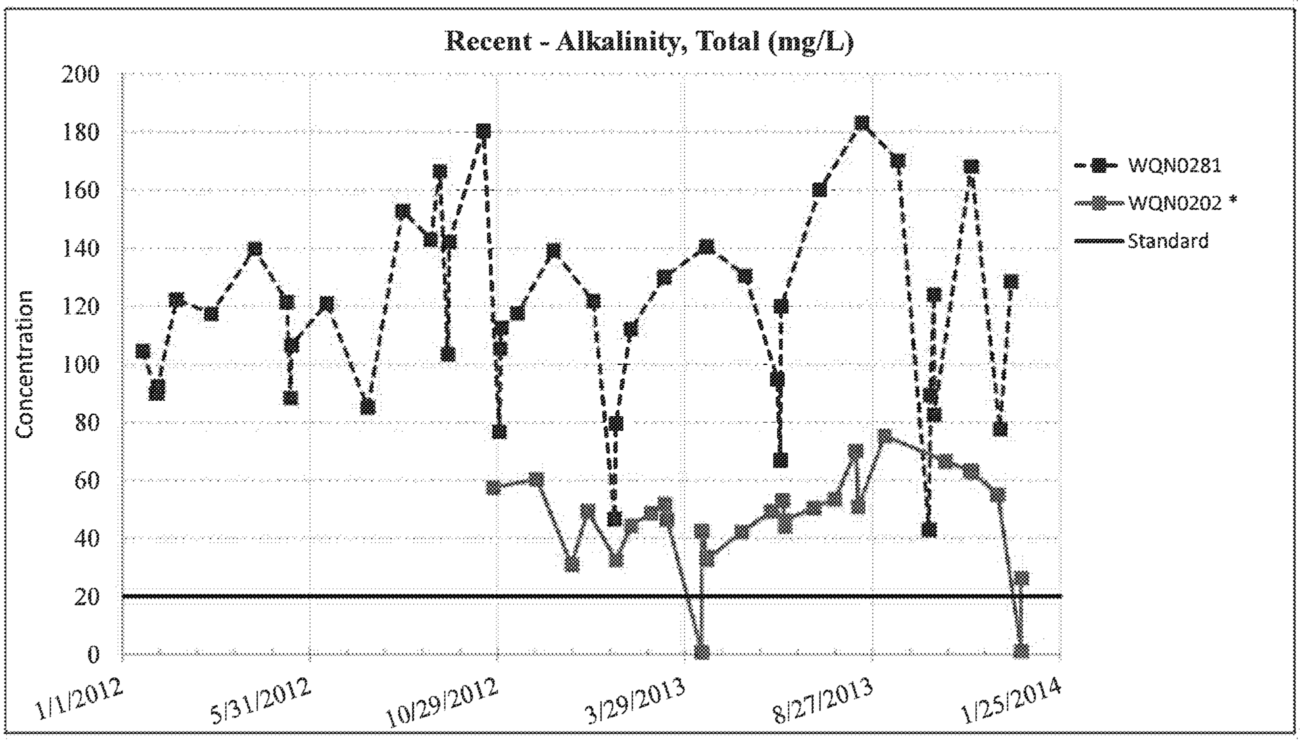
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Concentration
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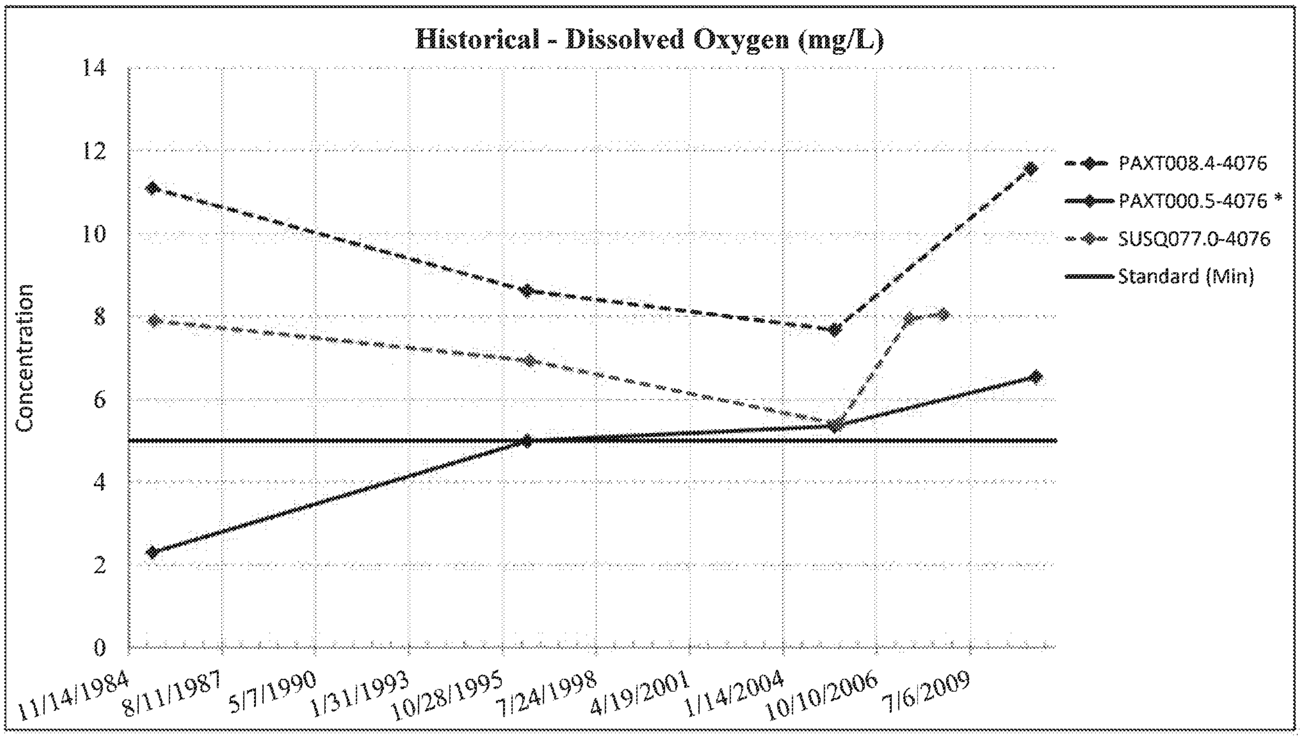
WQN0202 *
Standard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1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
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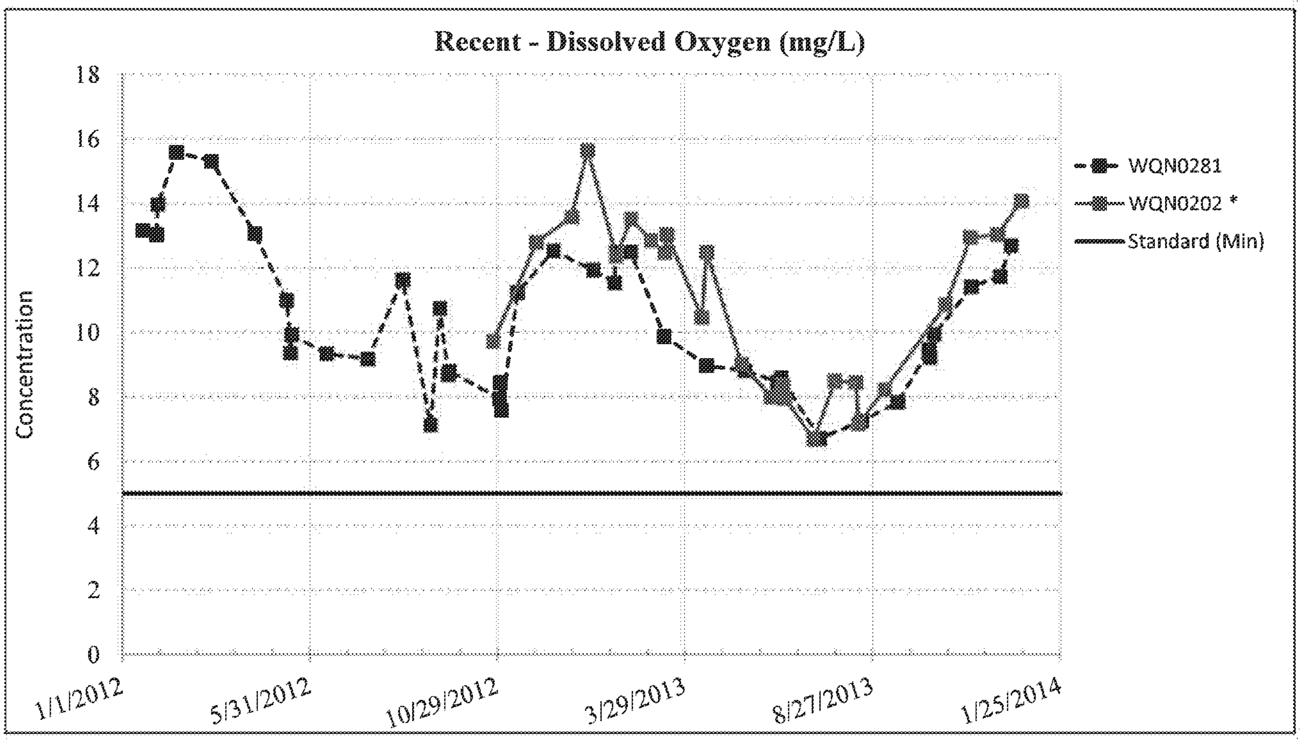
SUSQ077.0-4076
Standard (Min)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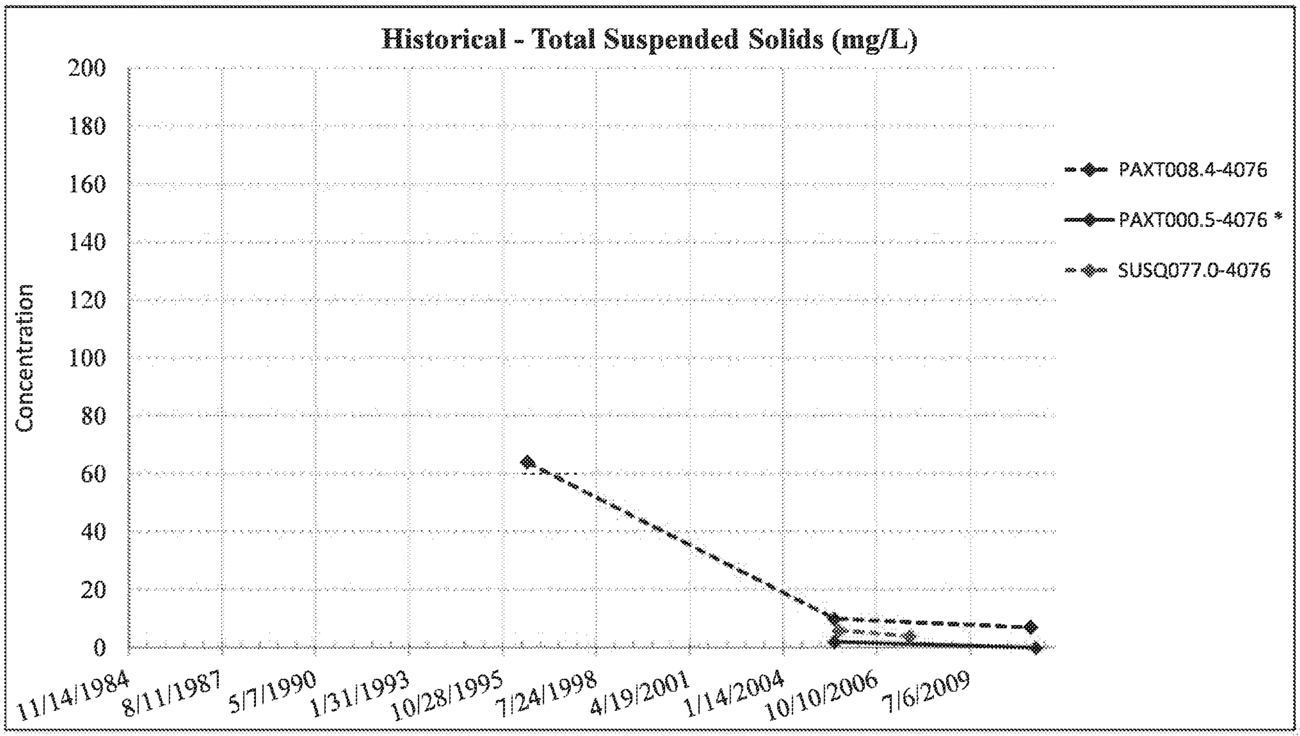
WQN0202 *
Standard (Min)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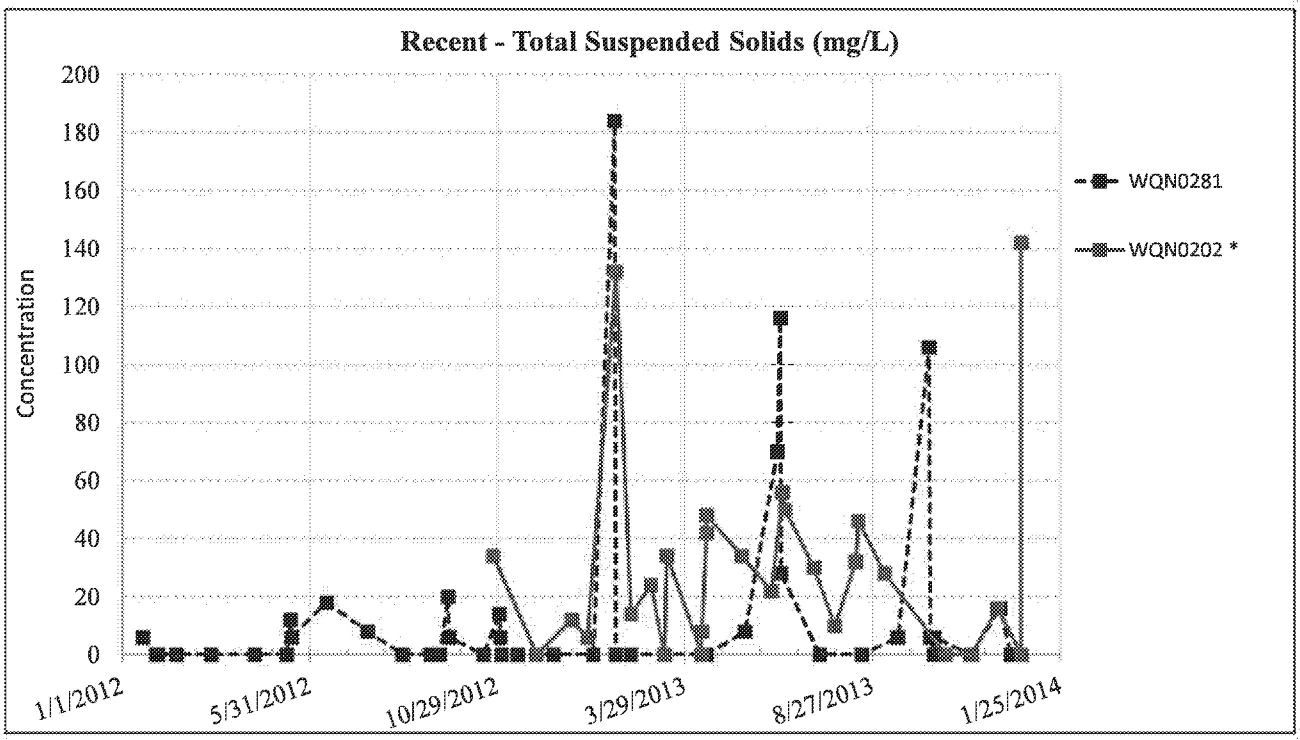
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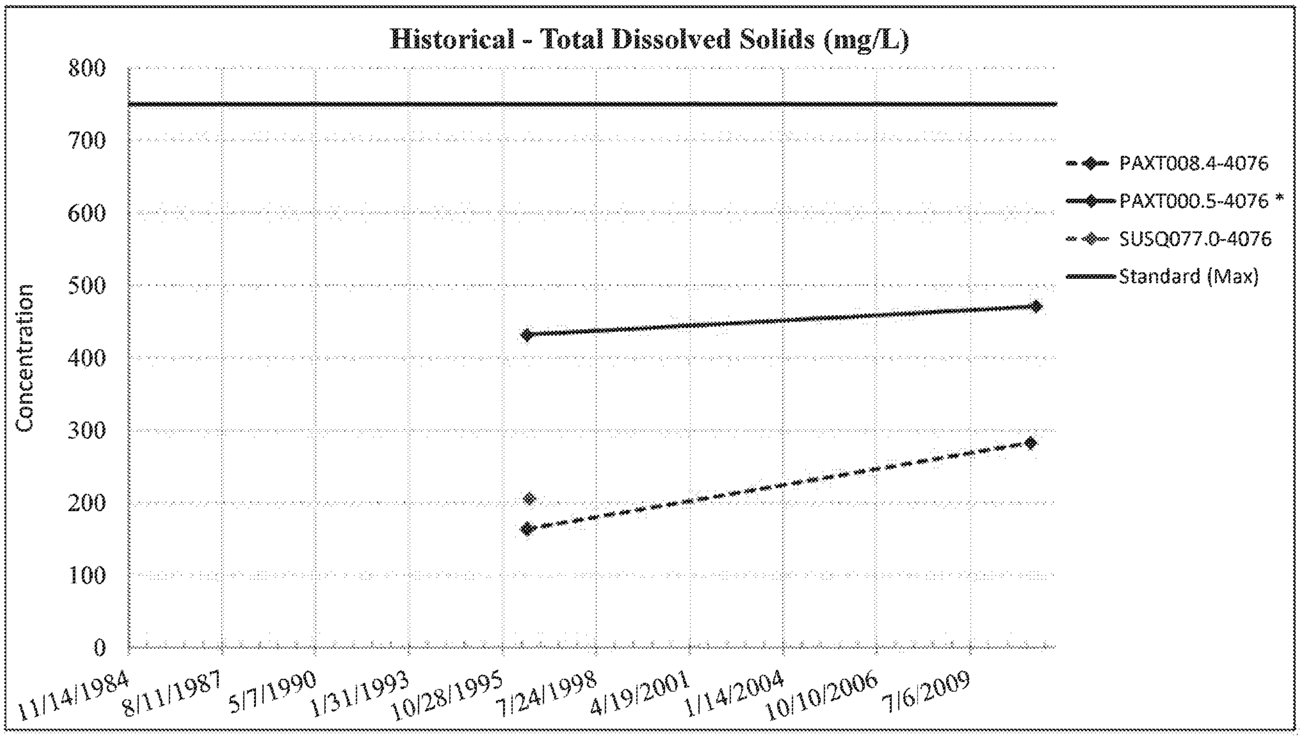
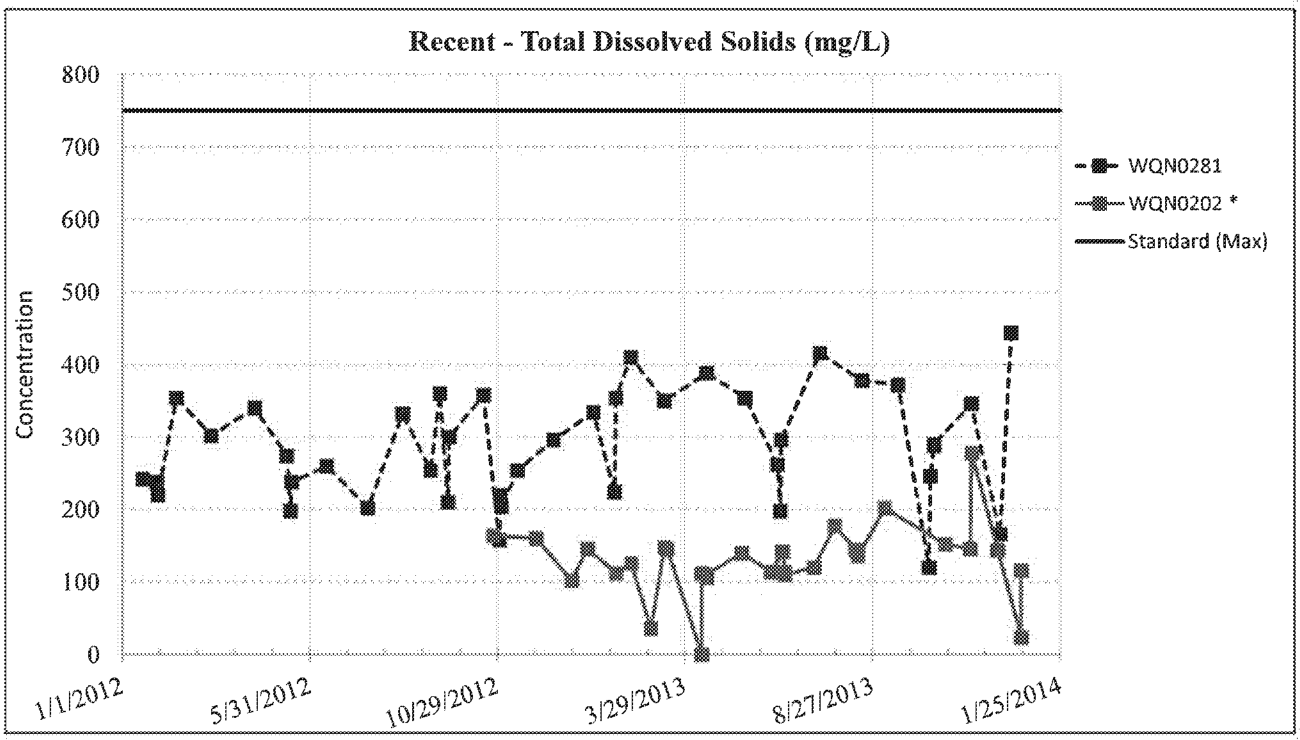
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *





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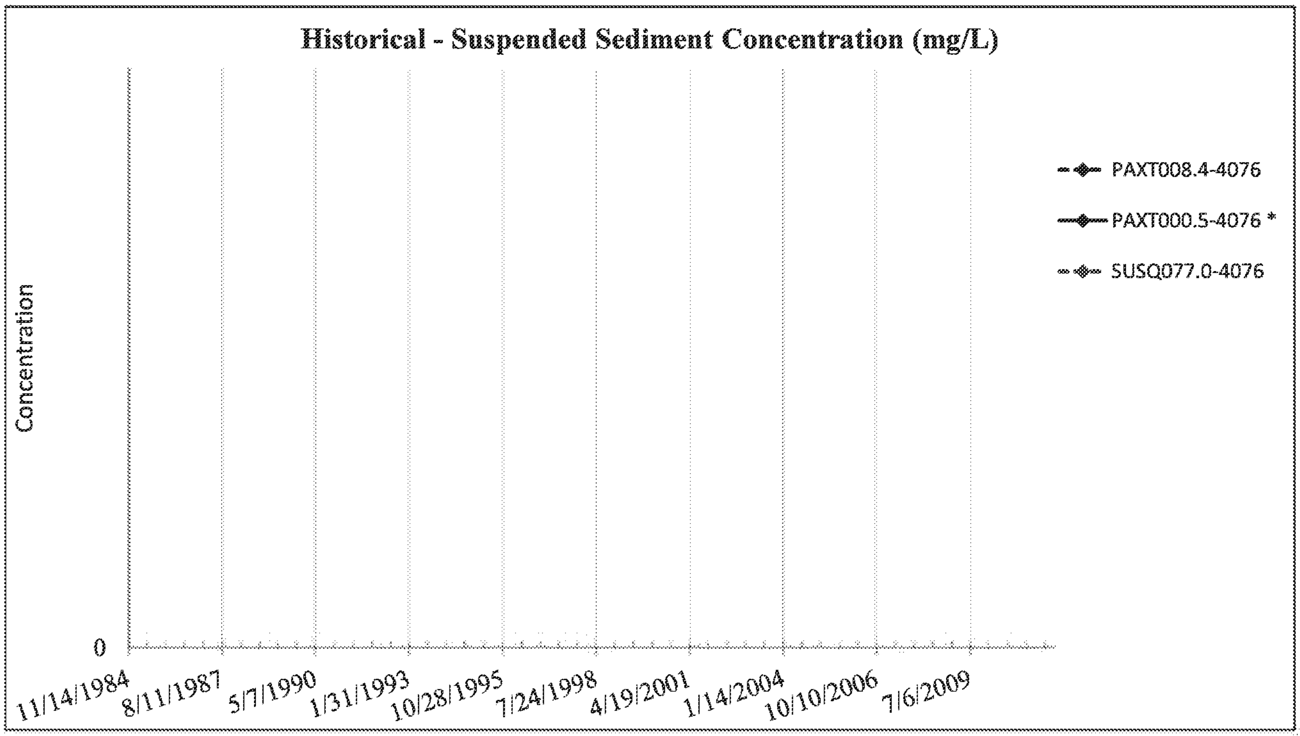
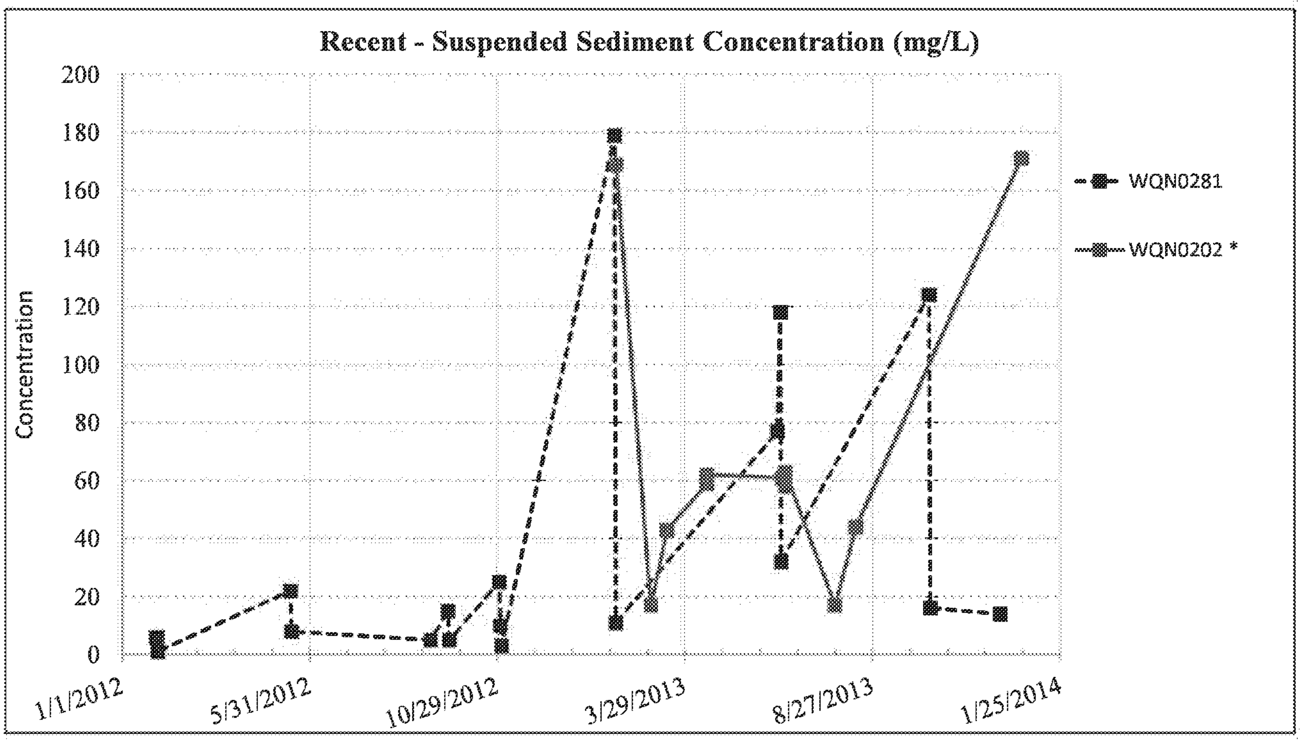
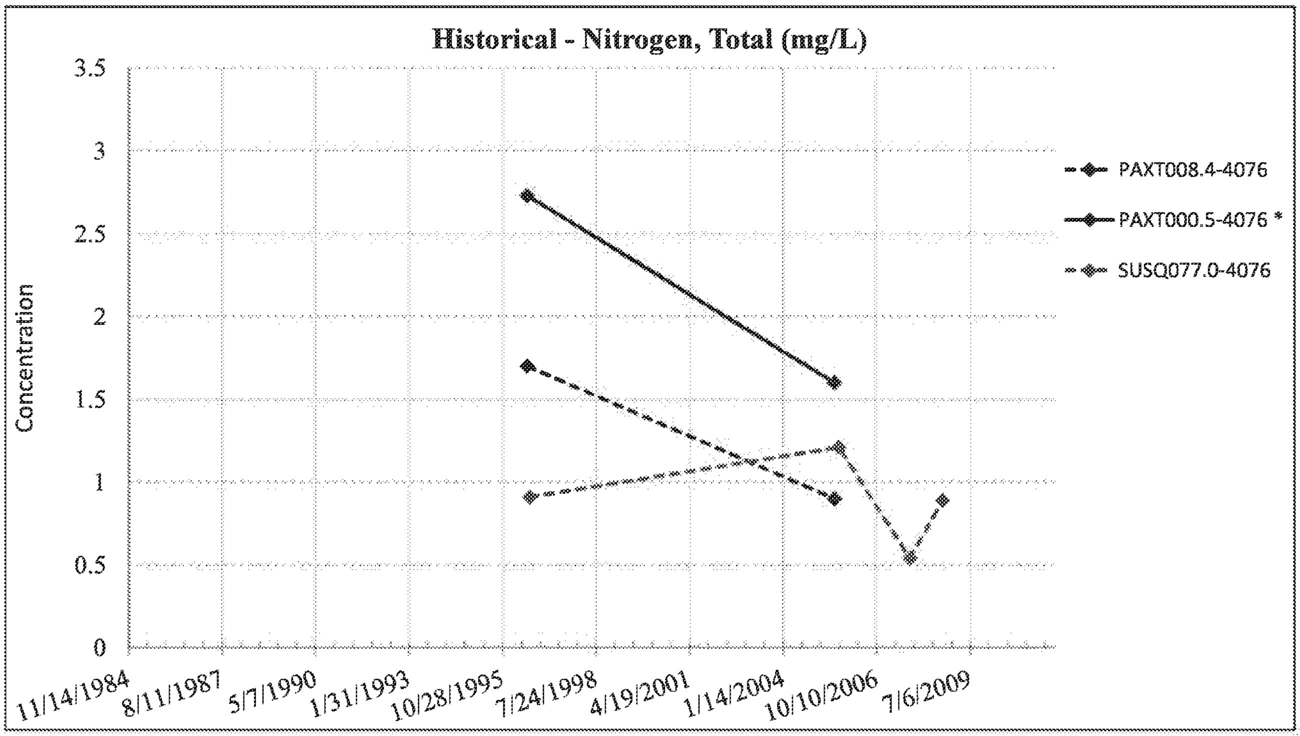
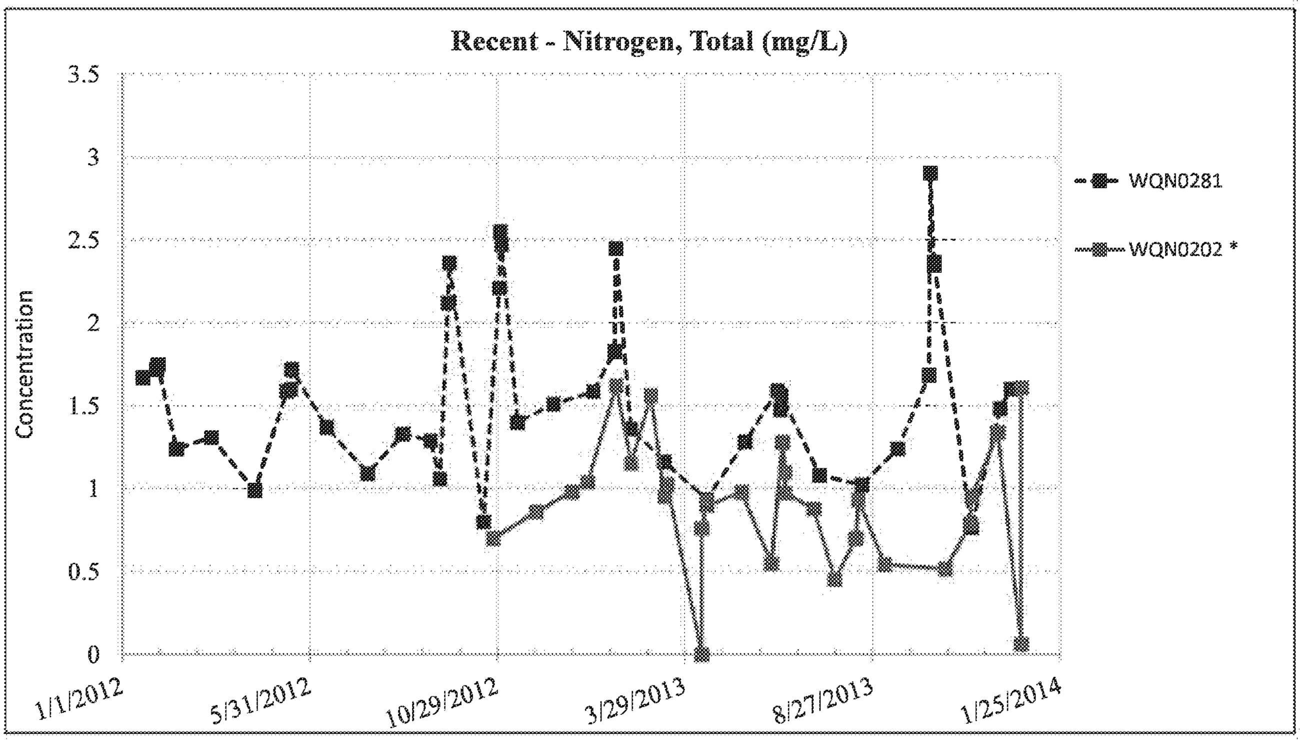

Historical - Suspended Sediment Concentration (mg/L)
Concentration
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Suspended Sediment Concentration (mg/L)
Concentration
200
180
160
140
120
100
80
60
40
20
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *





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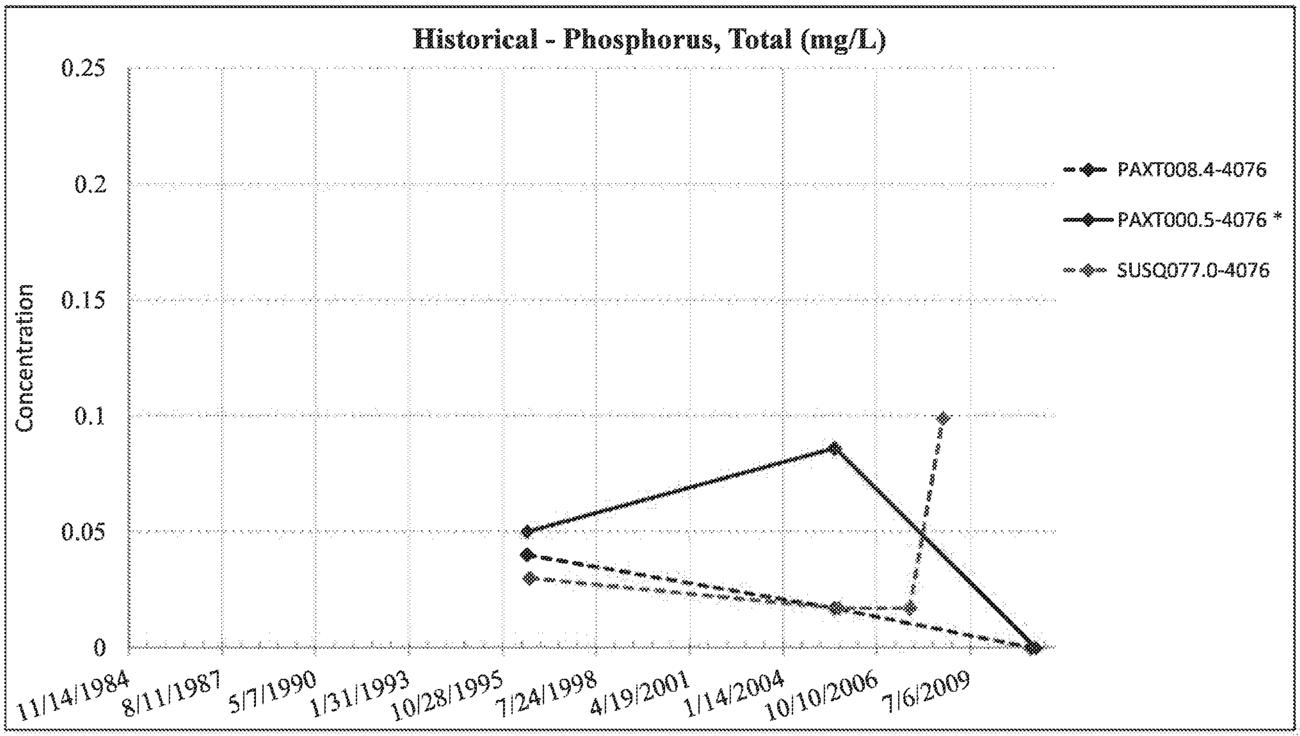
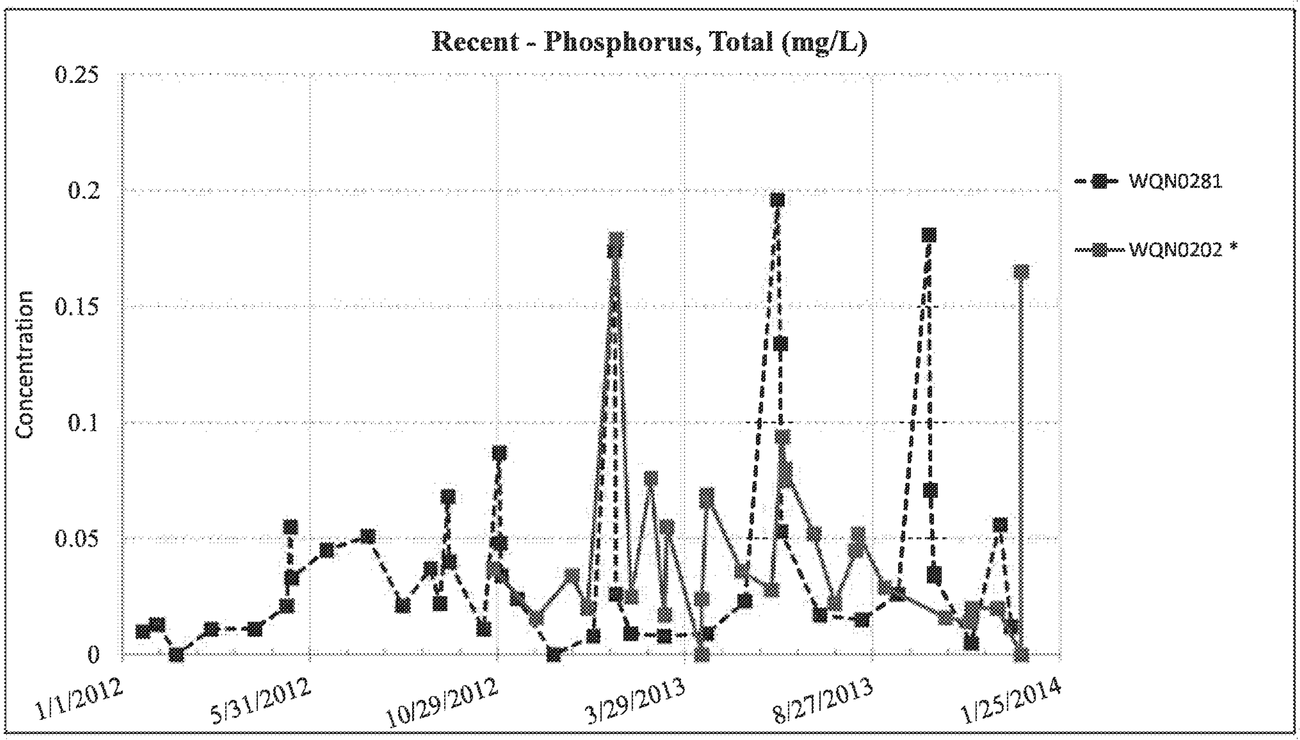
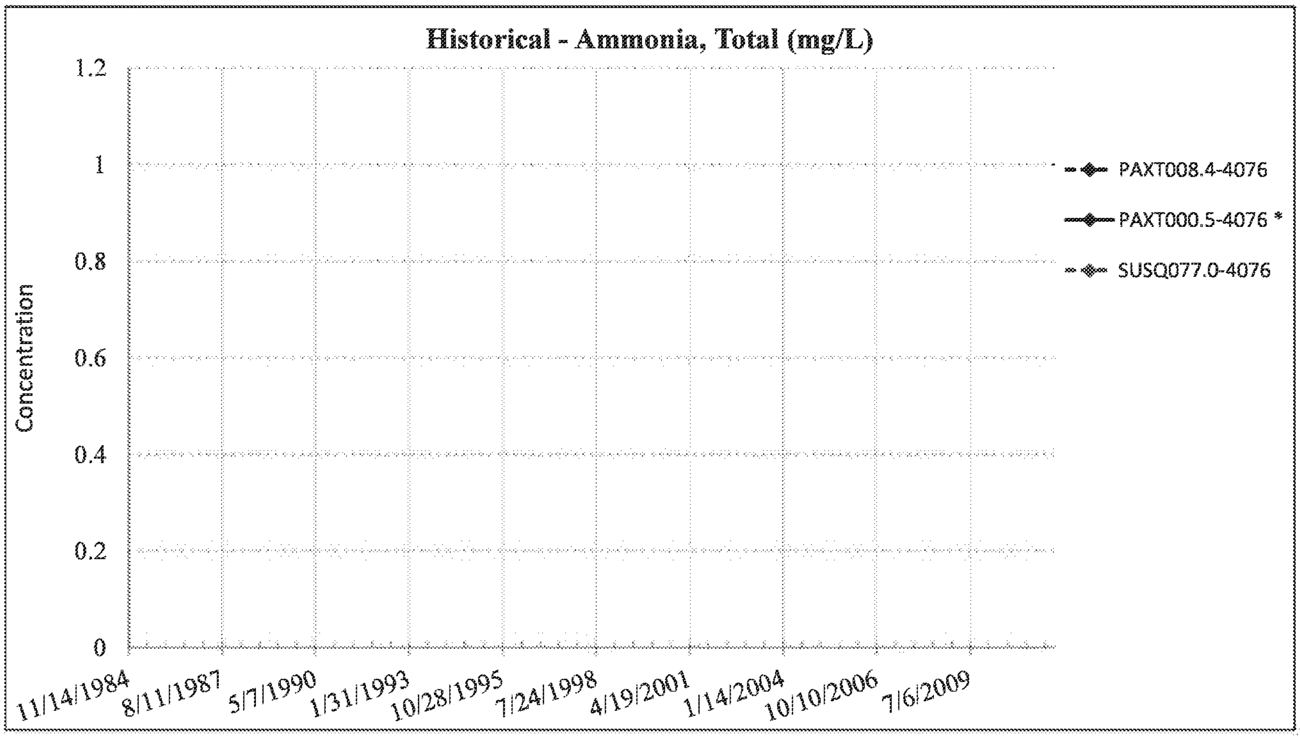
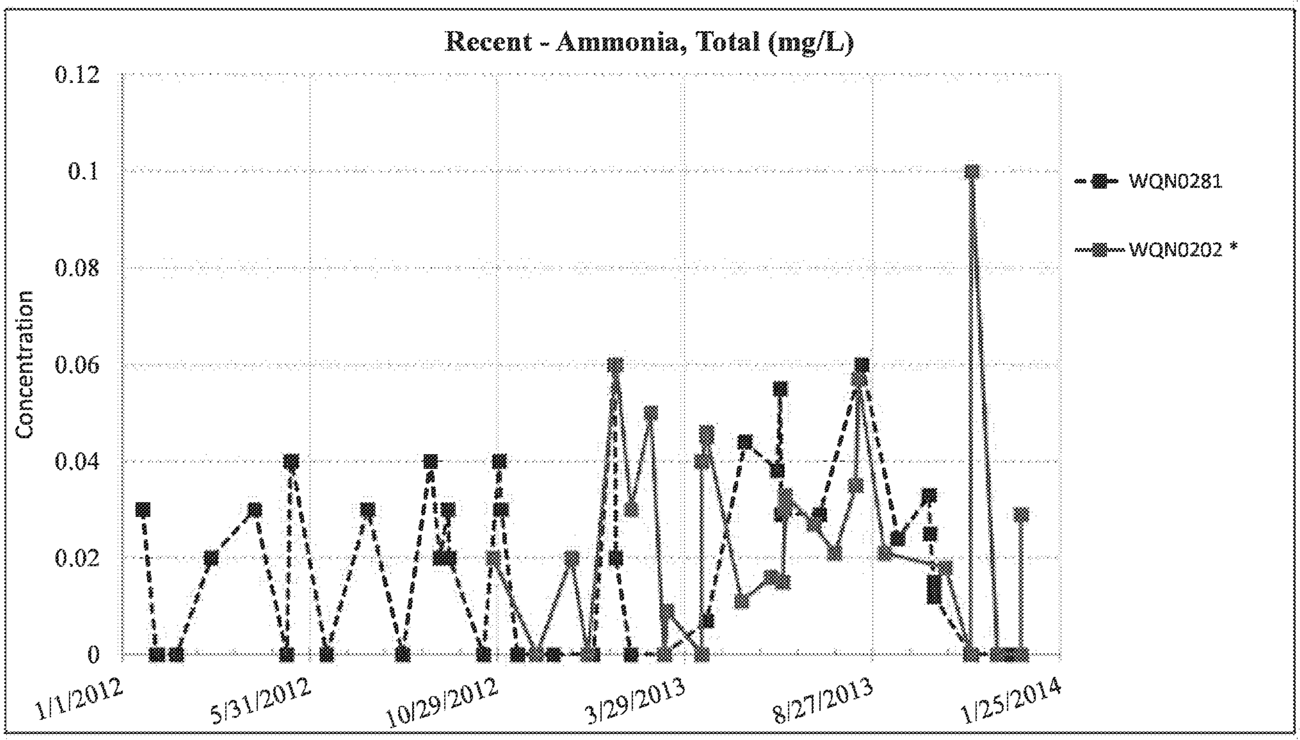
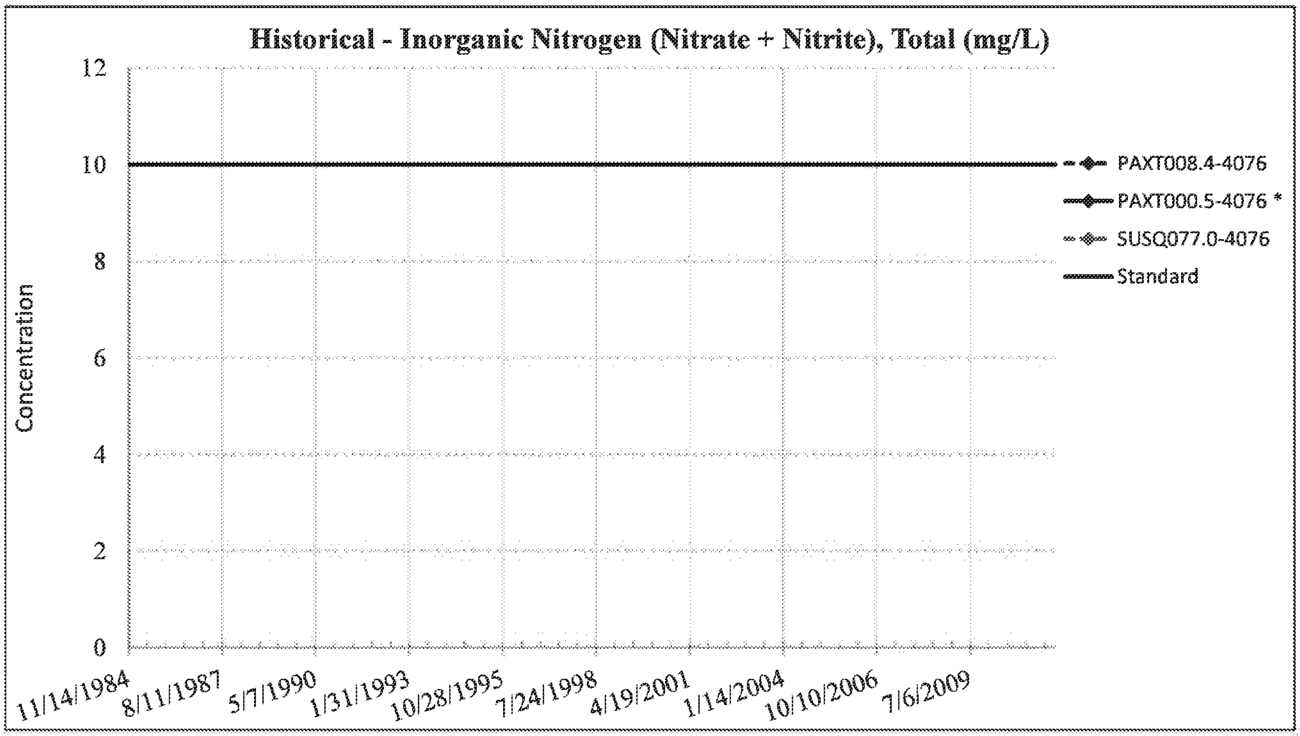
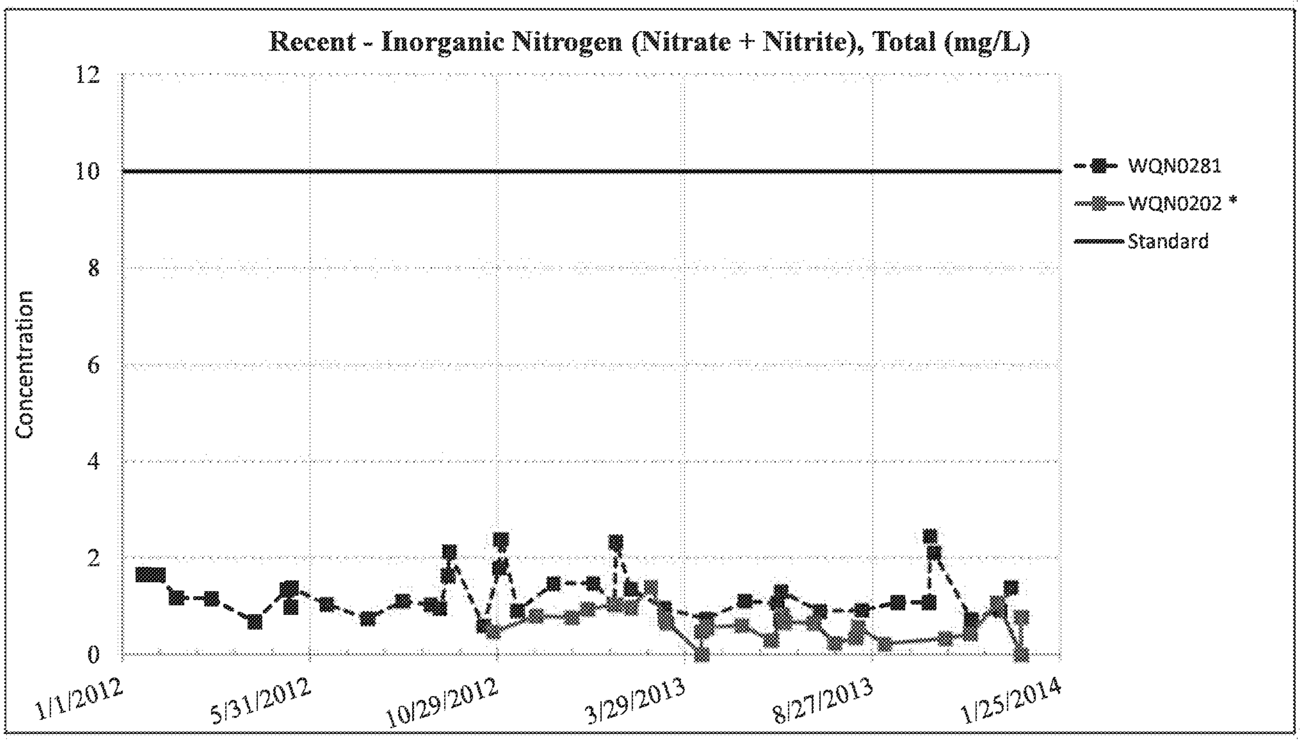

Historical - Phosphorus, Total (mg/L)
Concentration
0.25
0.2
0.15
0.1
0.05
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Phosphorus, Total (mg/L)
Concentration
0.25
0.2
0.15
0.1
0.05
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *


Historical - Ammonia, Total (mg/L)
Concentration
1.2
1
0.8
0.6
0.4
0.2
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Ammonia, Total (mg/L)
Concentration
0.12
0.1
0.08
0.06
0.04
0.02
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *





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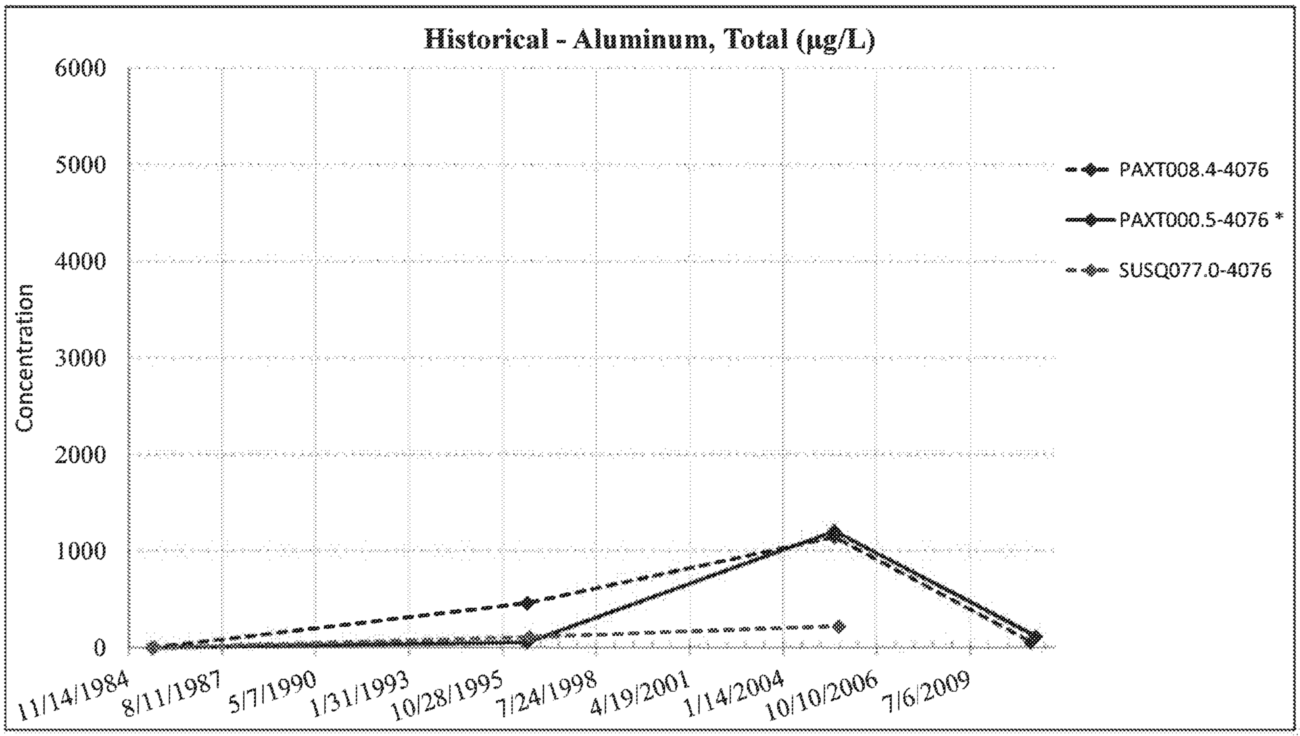
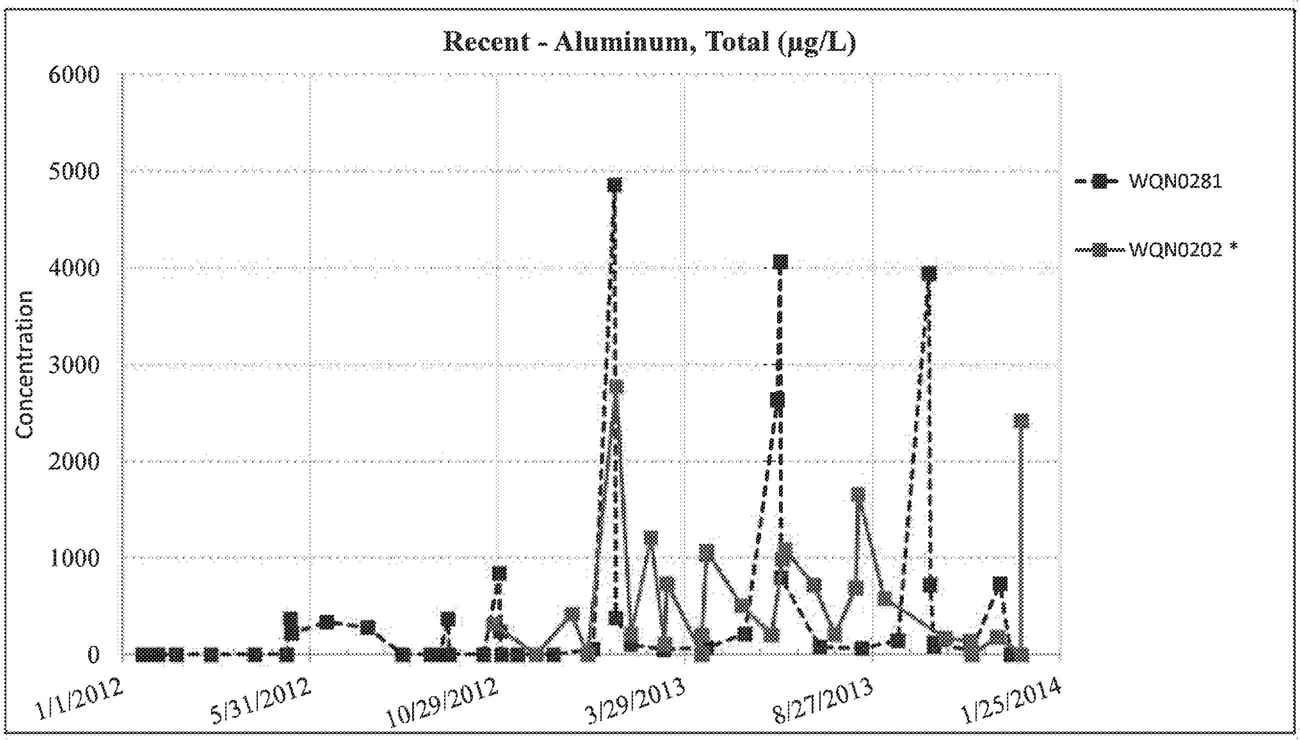
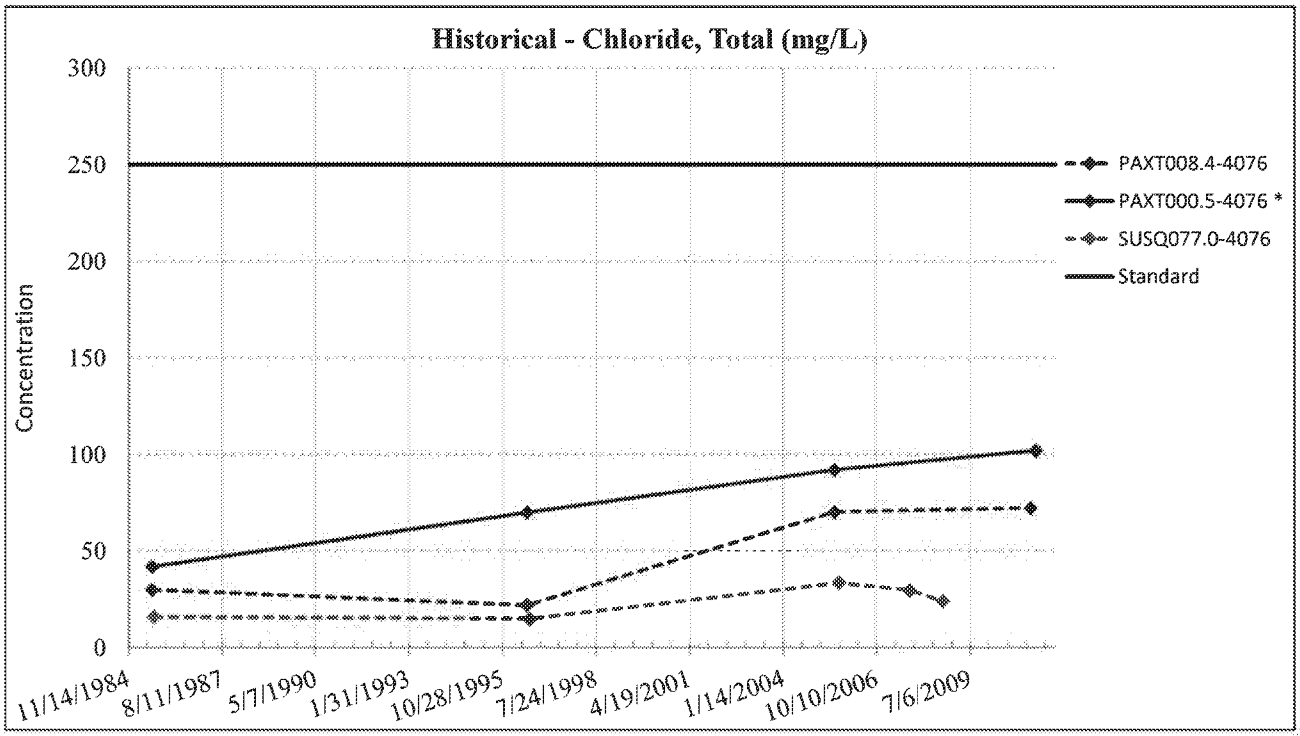
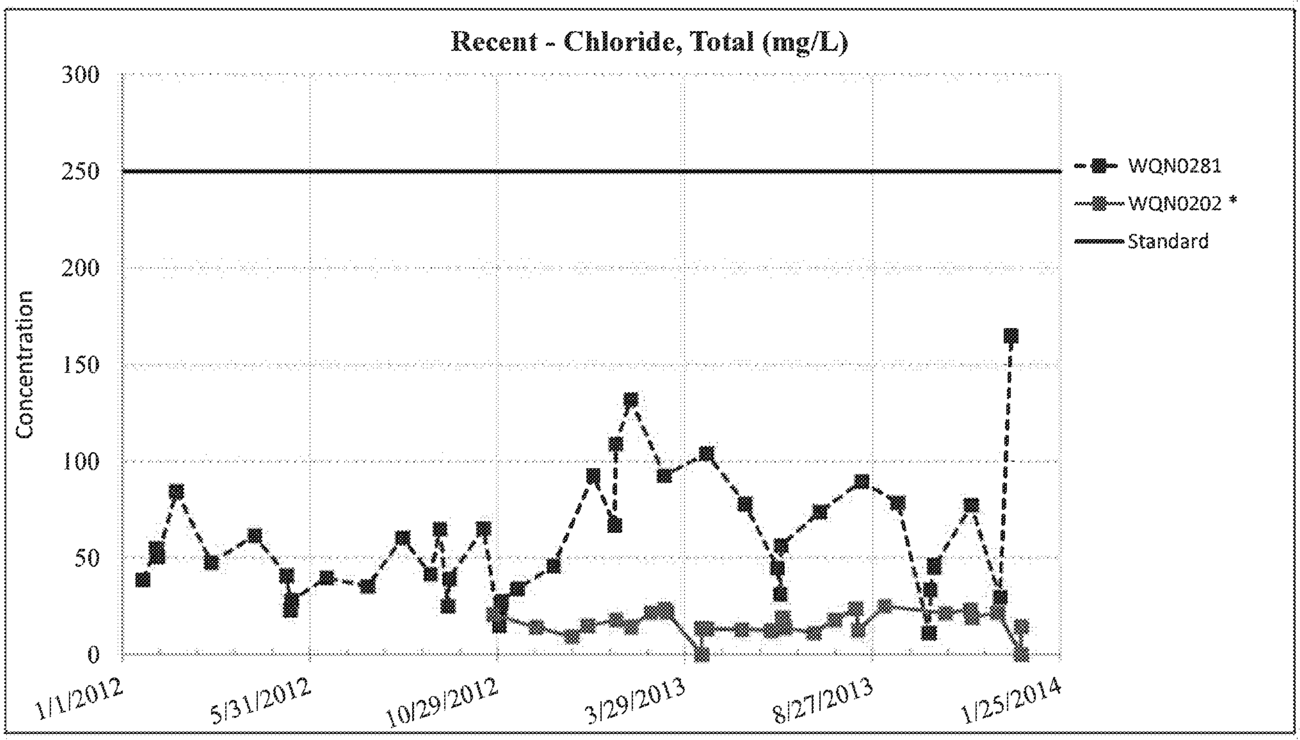
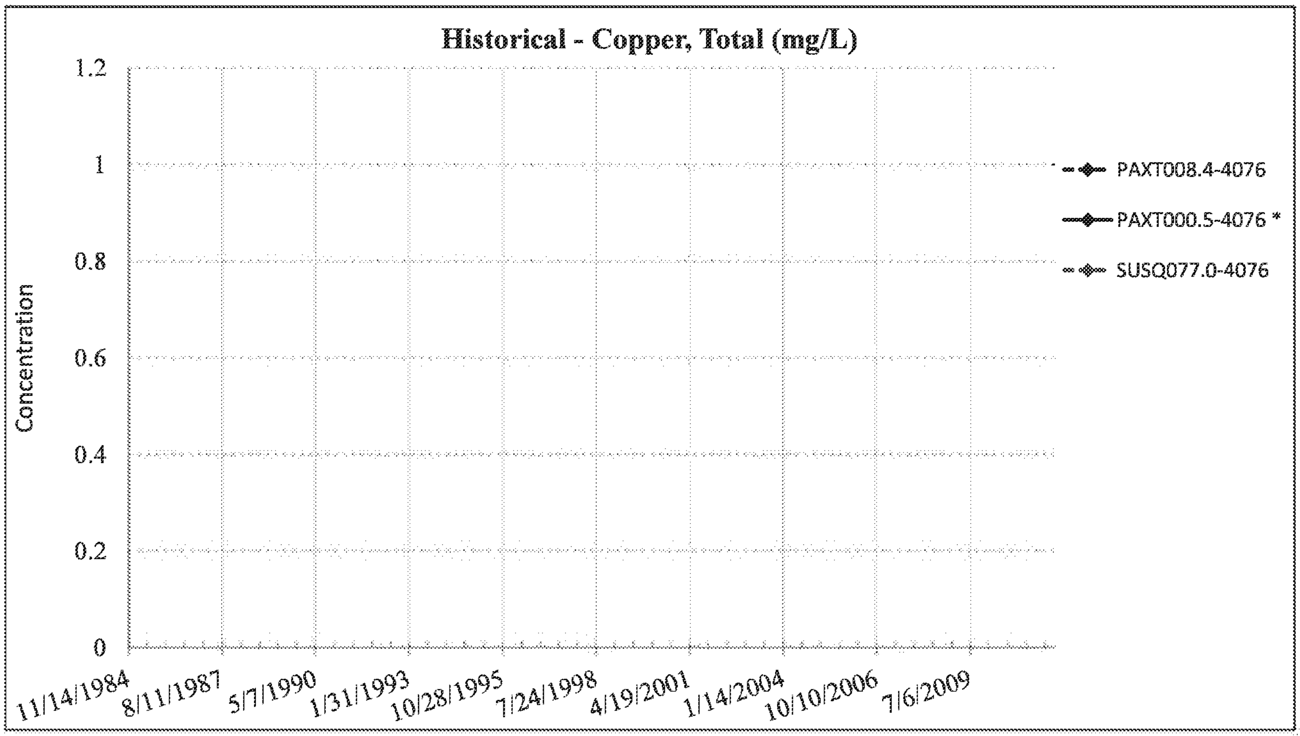
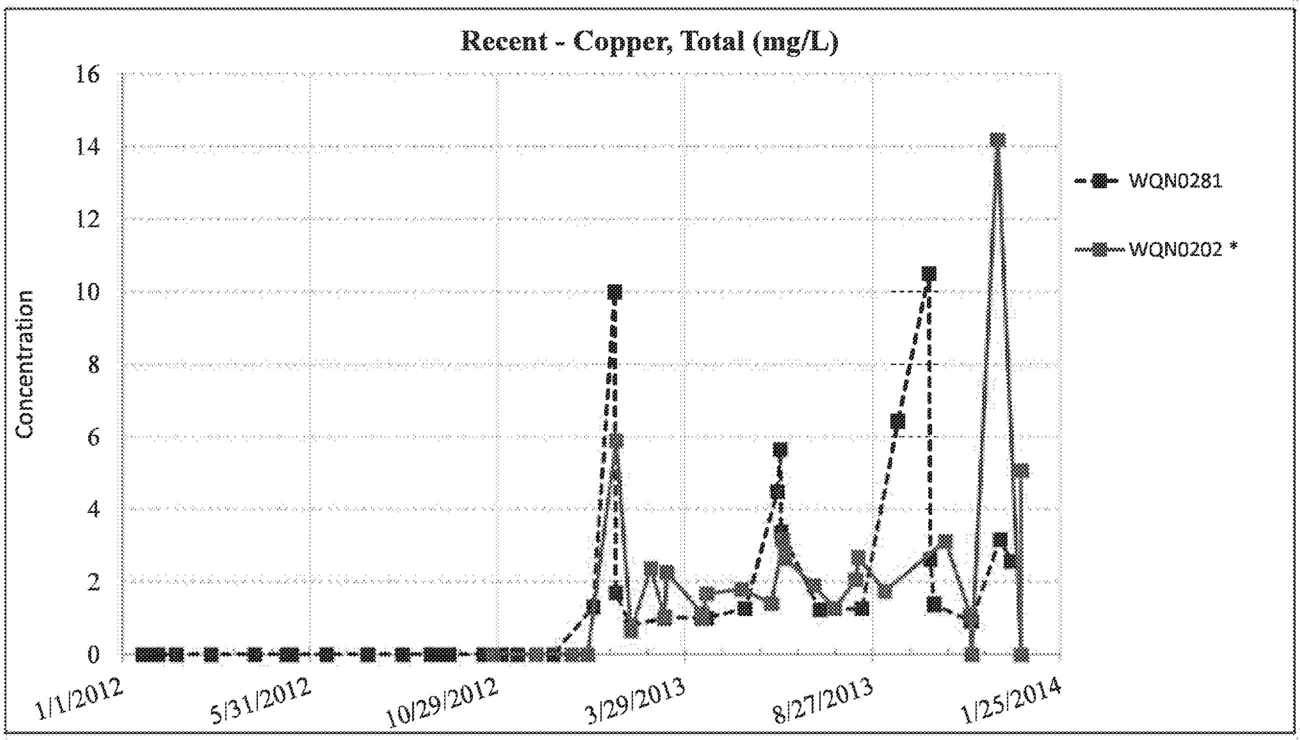

Historical - Aluminum, Total (µg/L)
Concentration
6000
5000
4000
3000
2000
1000
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076

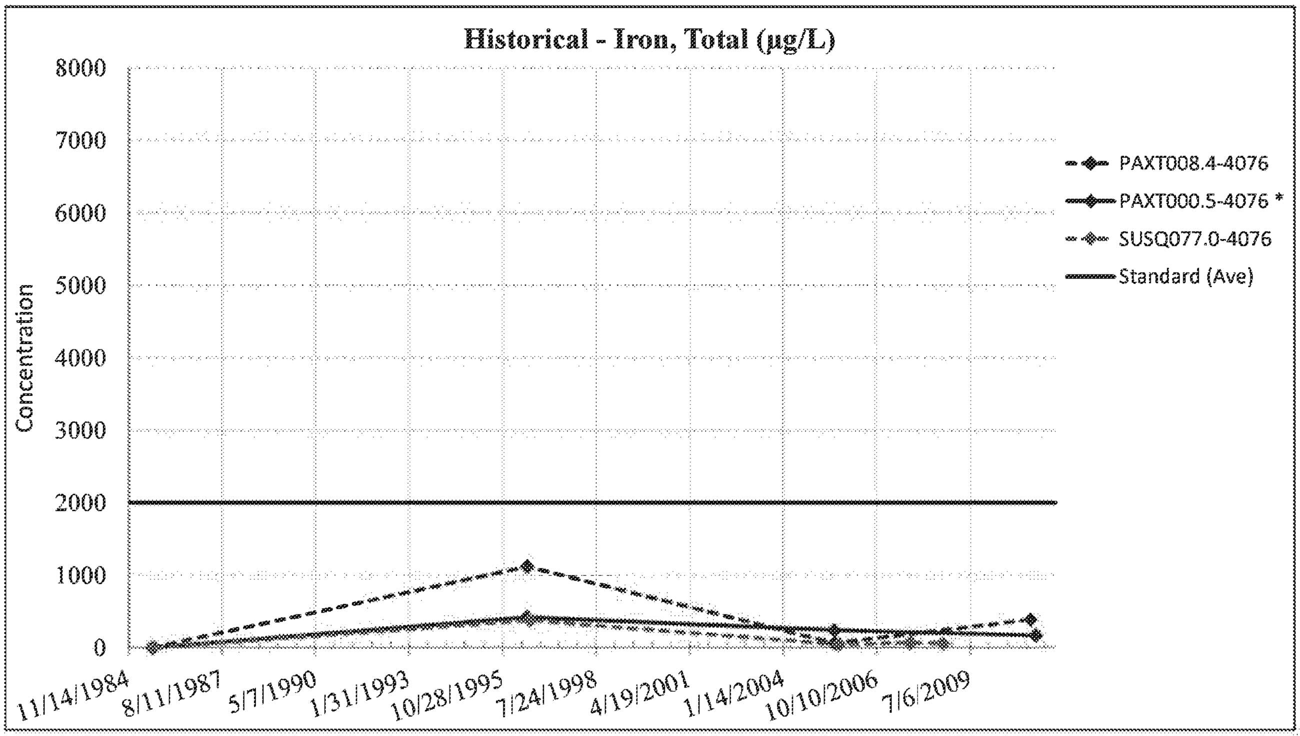

Recent - Aluminum, Total (µg/L)
Concentration
6000
5000
4000
3000
2000
1000
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *

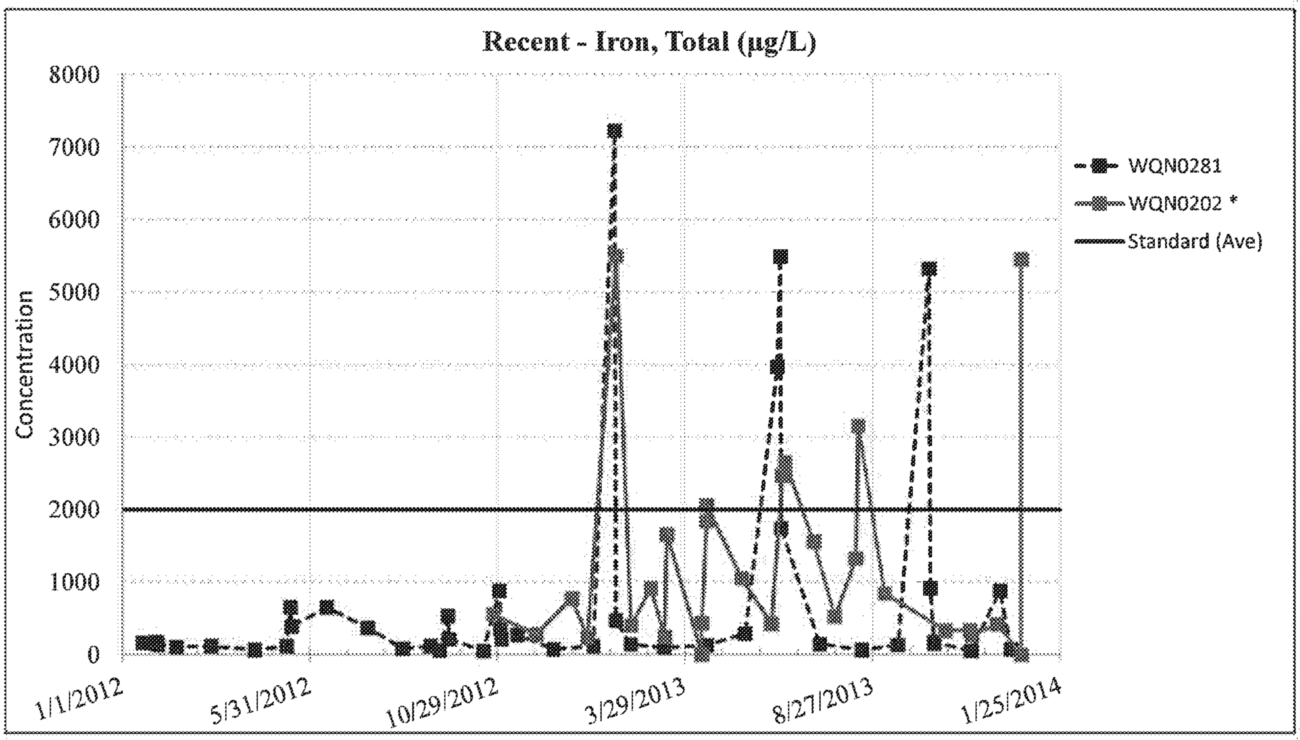

Historical - Chloride, Total (mg/L)
300
250
200
150
100
50
0
Concentration
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076
Standard


Recent - Chloride, Total (mg/L)
300
250
200
150
100
50
0
Concentration
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *
Standard


Historical - Copper, Total (mg/L)
Concentration
1.2
1
0.8
0.6
0.4
0.2
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Copper, Total (mg/L)
Concentration
16
14
12
10
8
6
4
2
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *





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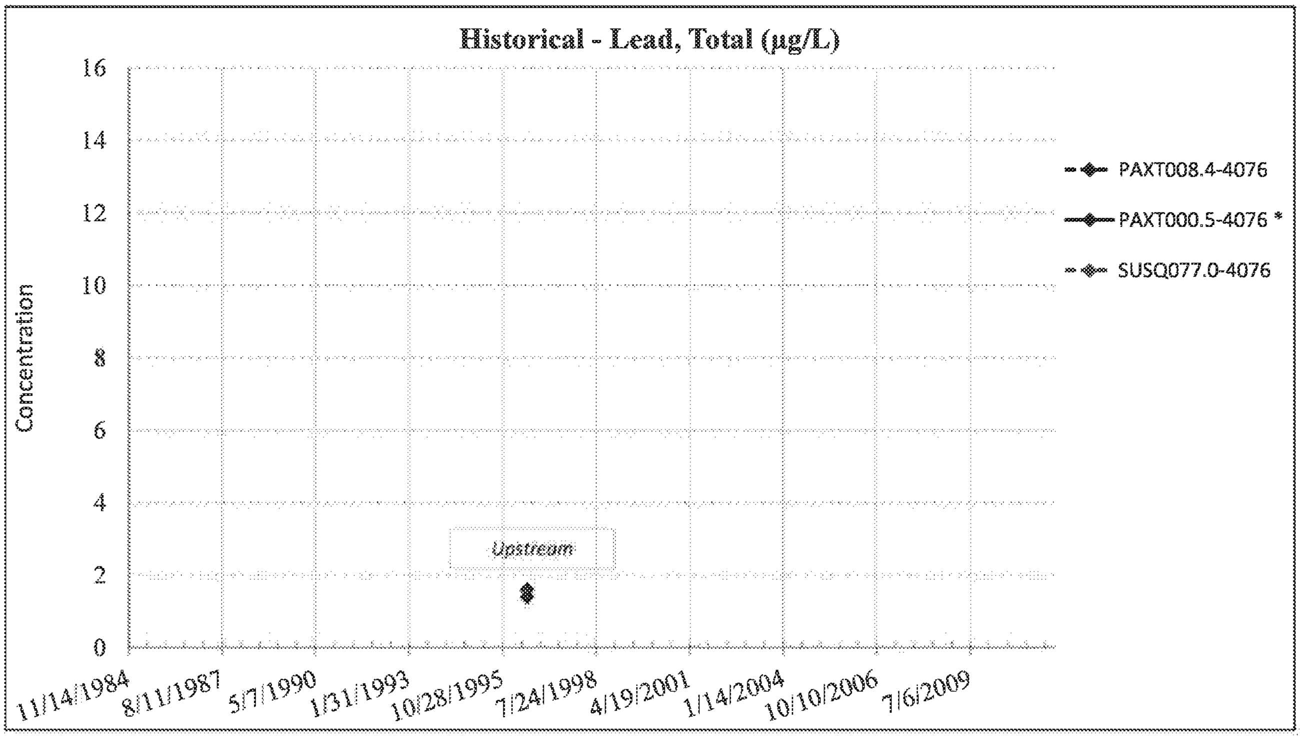
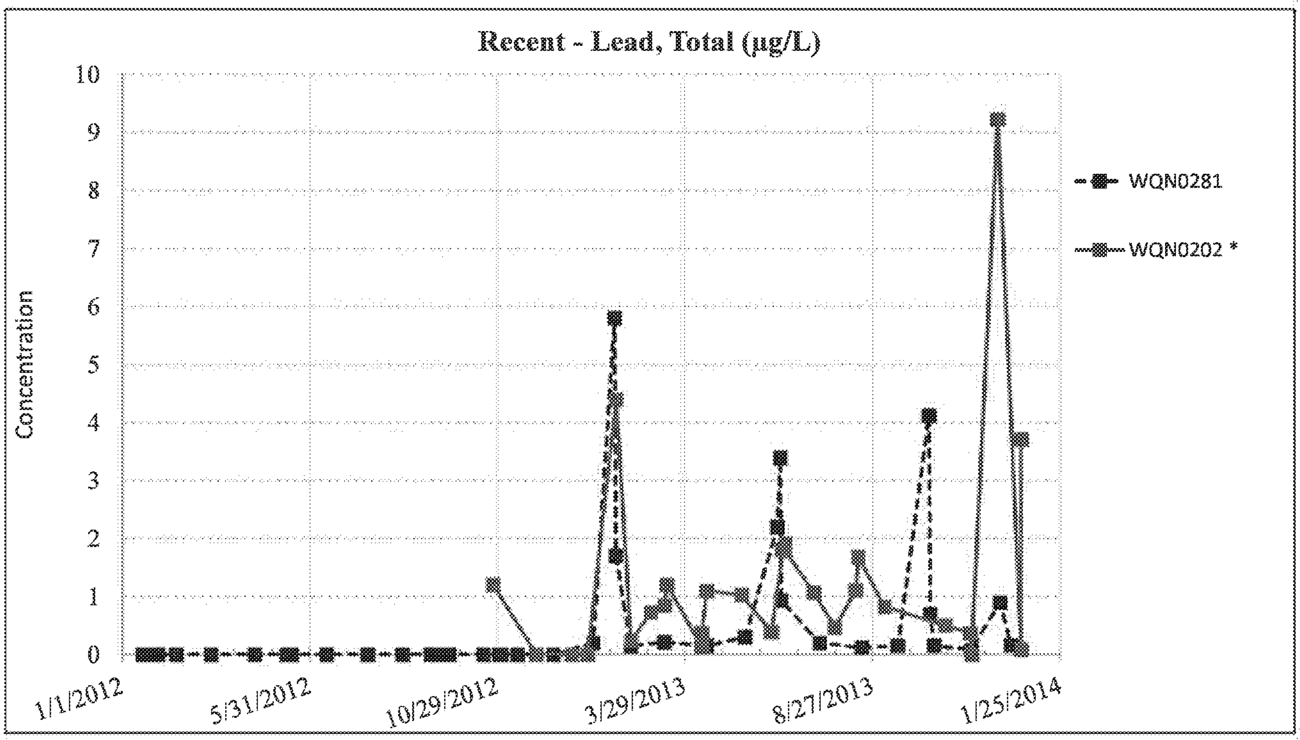
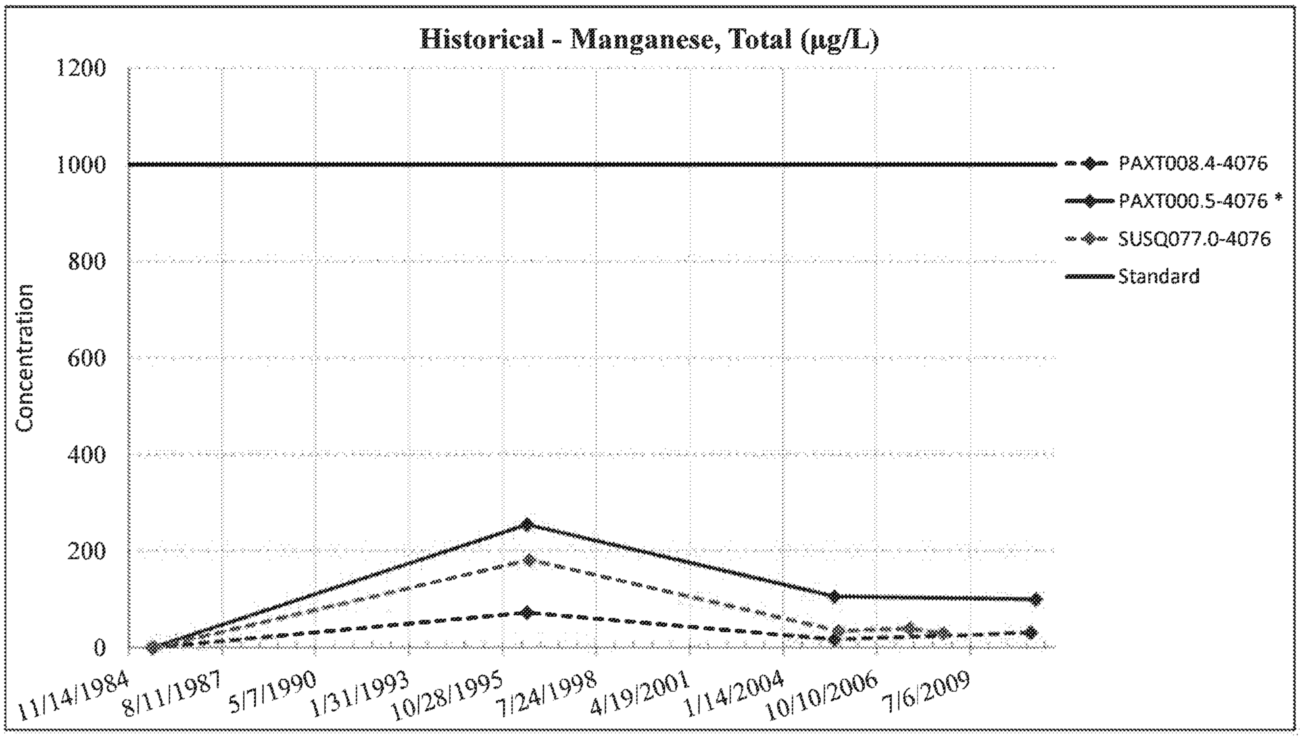
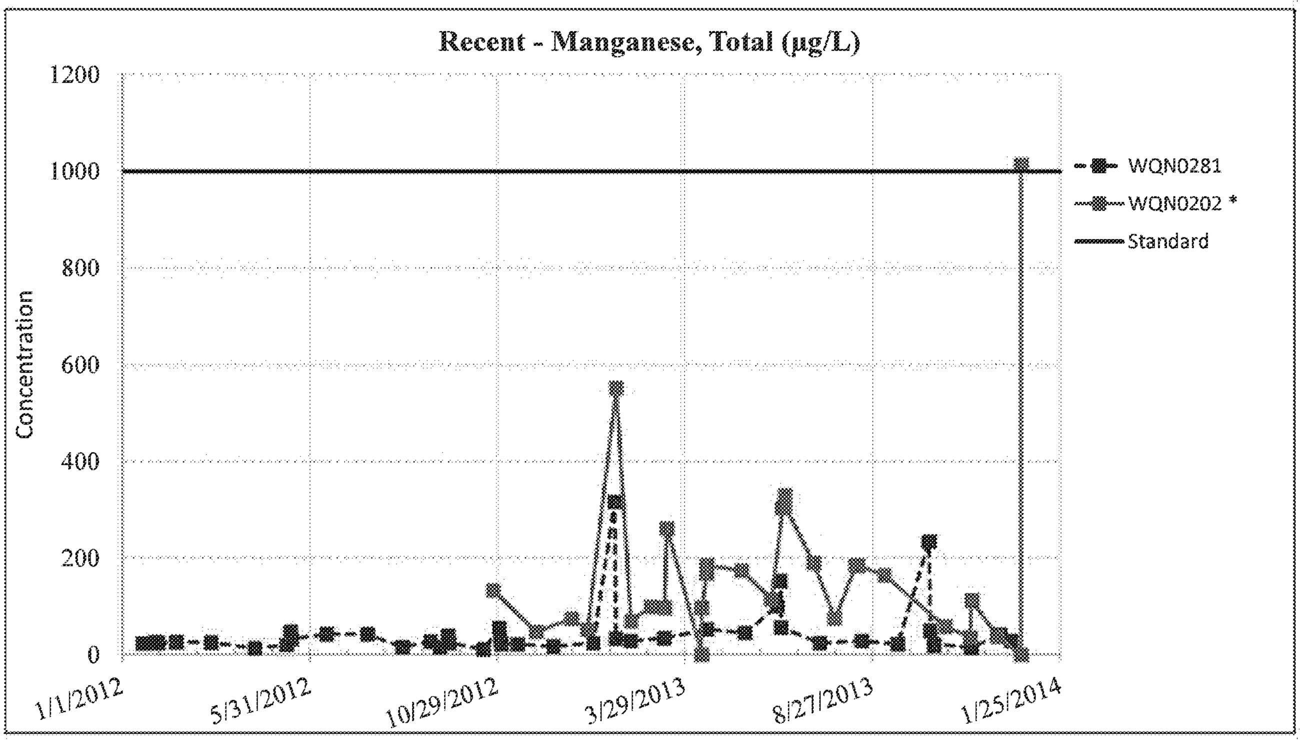
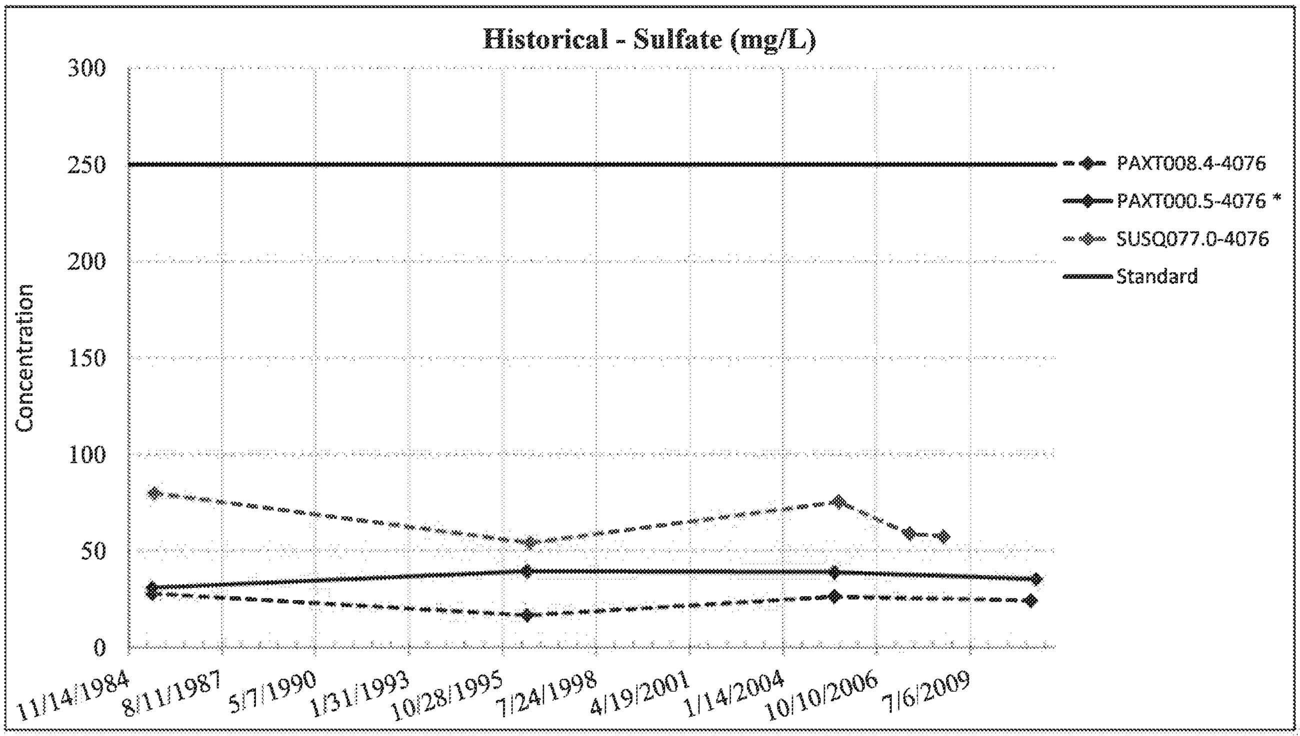
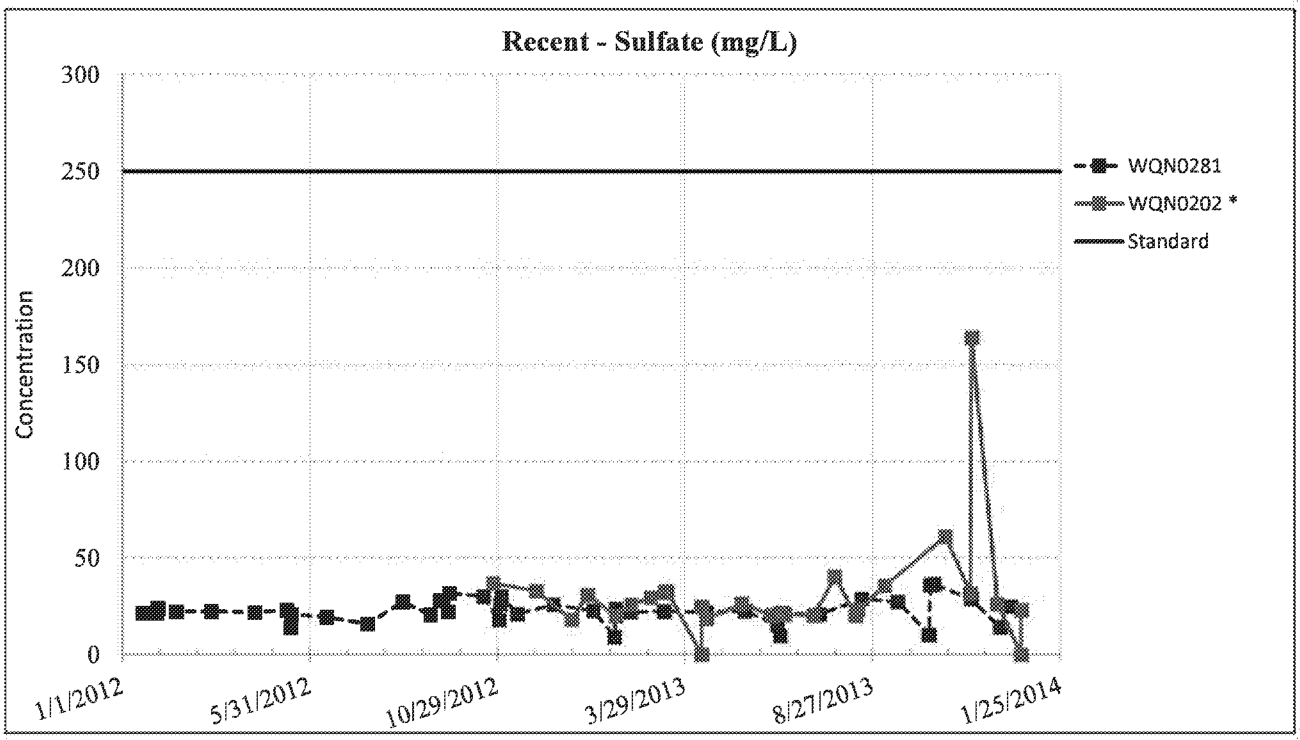

Historical - Lead, Total (µg/L)
Concentration
16
14
12
10
8
6
4
2
0
Upstream
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076

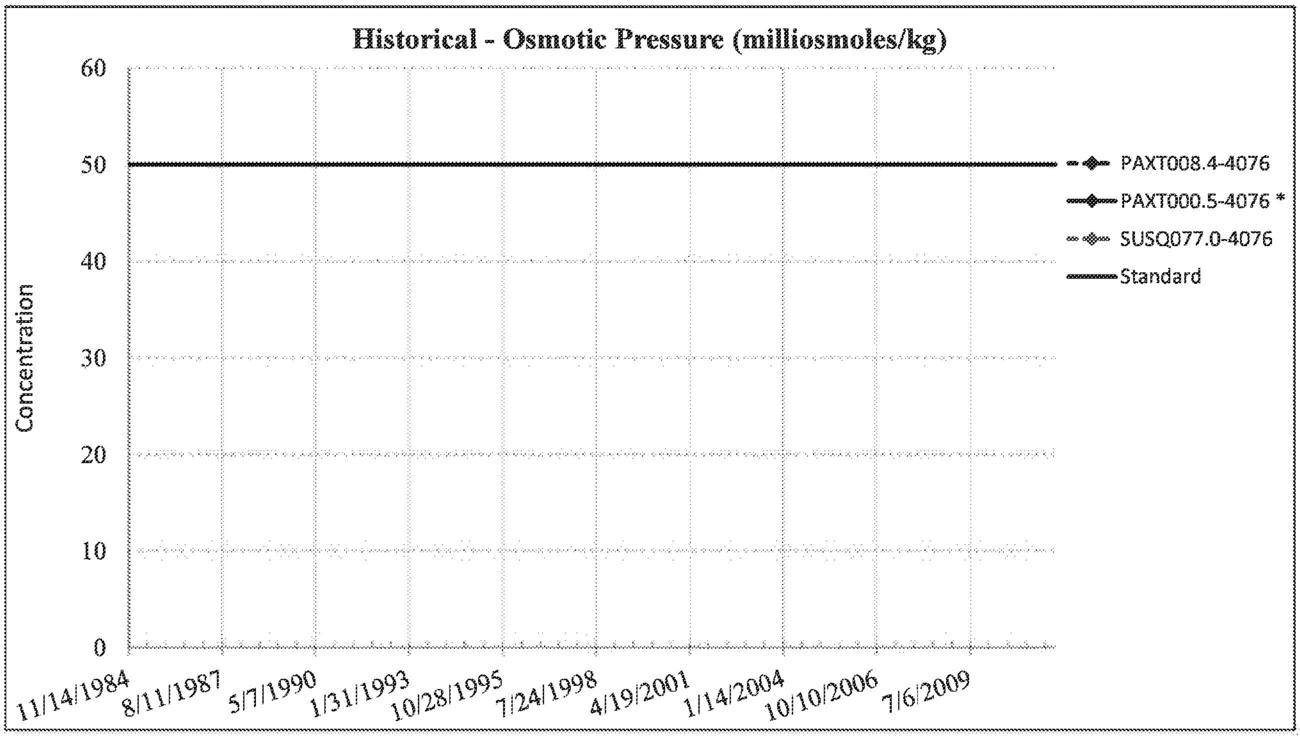

Recent - Lead, Total (µg/L)
Concentration
10
9
8
7
6
5
4
3
2
1
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *

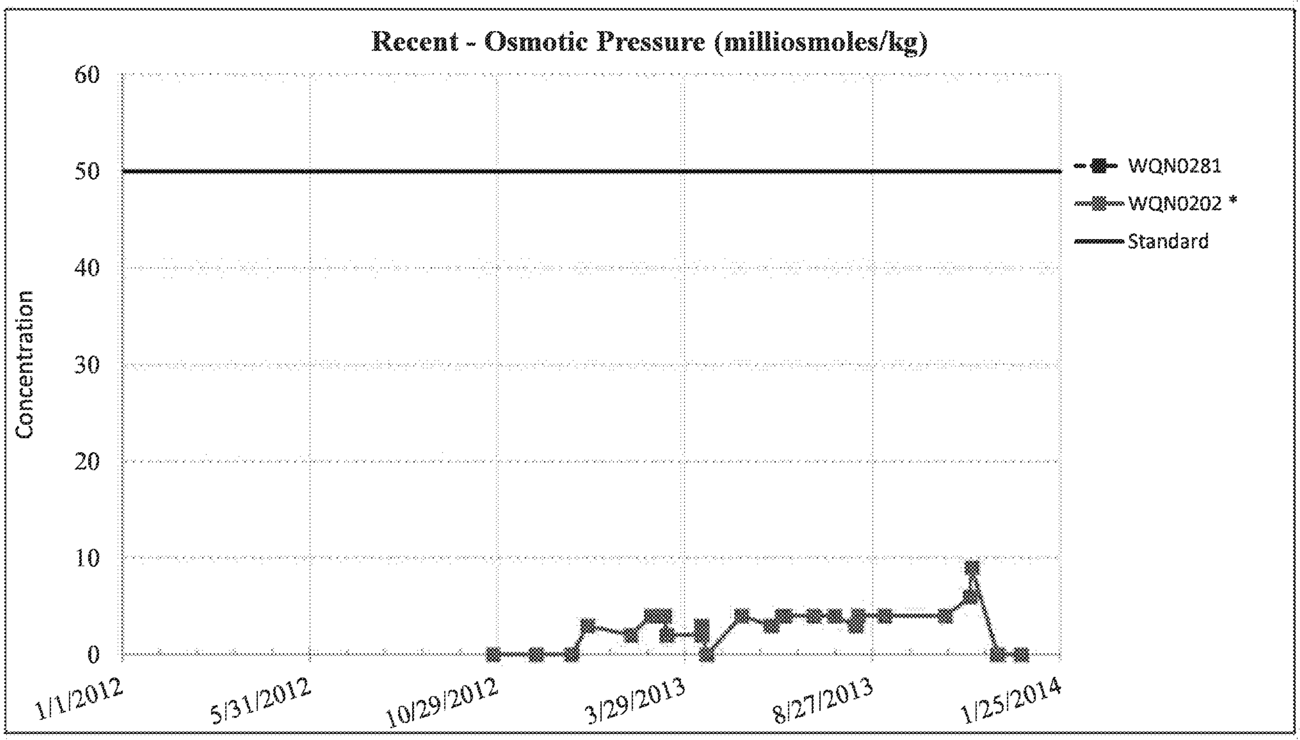

Historical - Manganese, Total (µg/L)
Concentration
1200
1000
800
600
400
200
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076
Standard

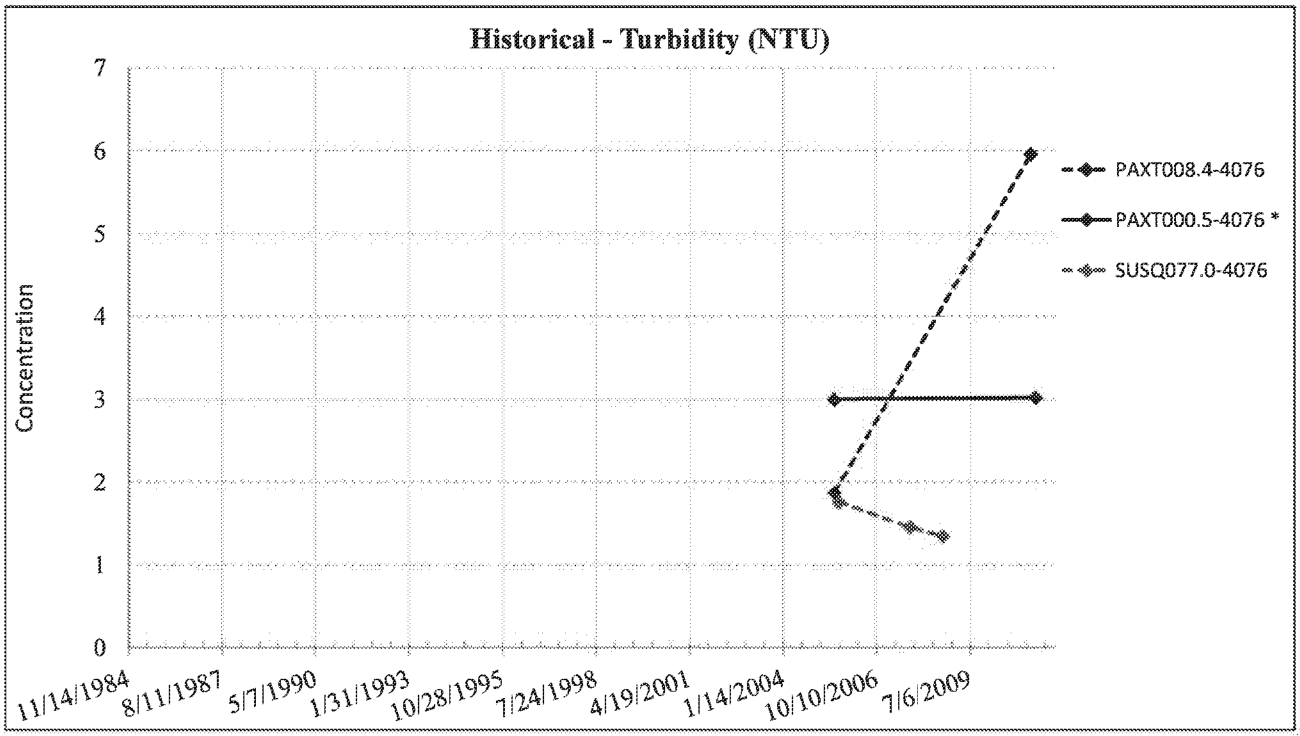

Recent - Manganese, Total (µg/L)
Concentration
1200
1000
800
600
400
200
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *
Standard

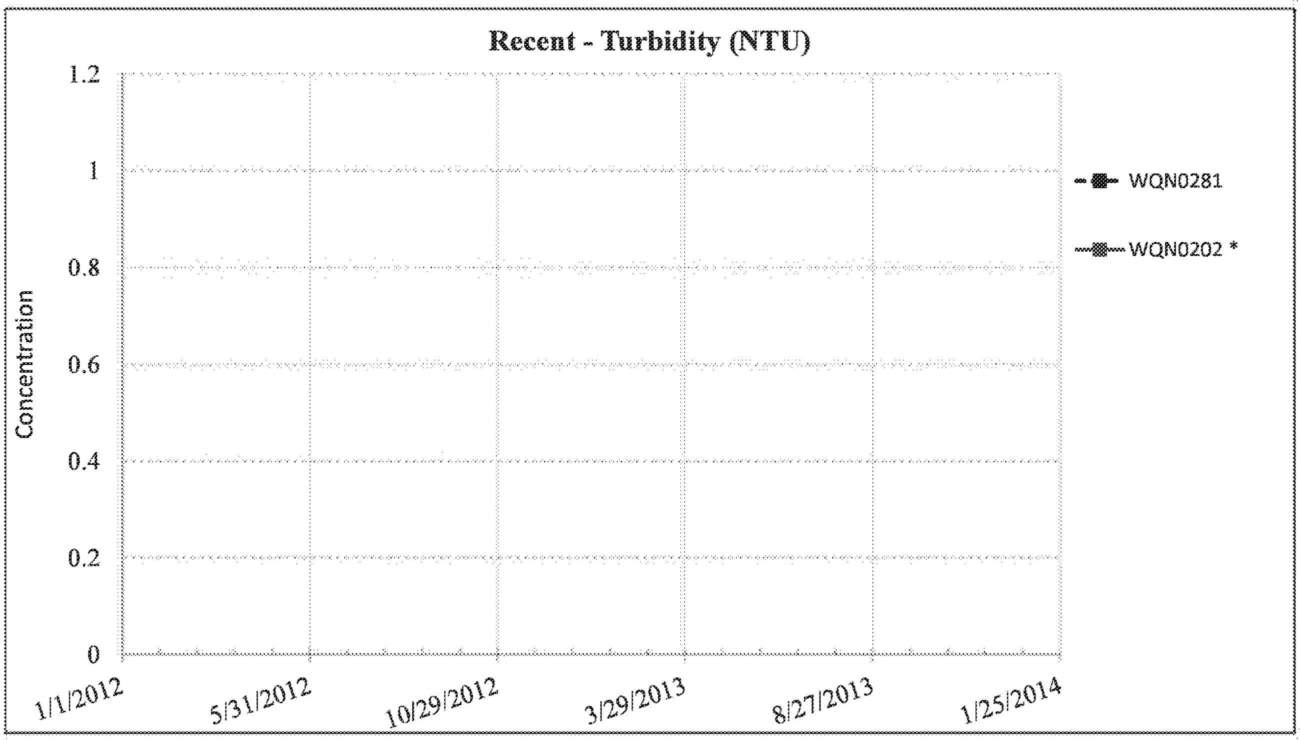

Historical - Sulfate (mg/L)
Concentration
300
250
200
150
100
50
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076
Standard

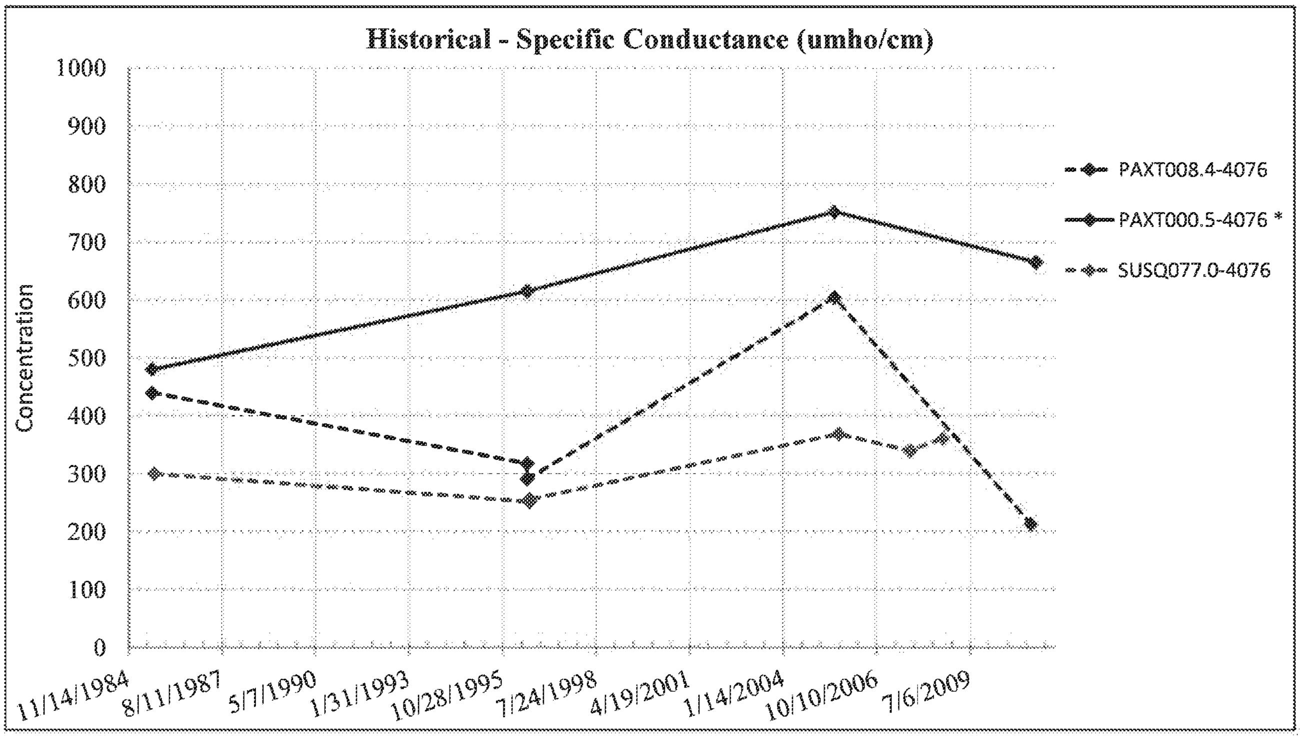

Recent - Sulfate (mg/L)
Concentration
300
250
200
150
100
50
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *
Standard

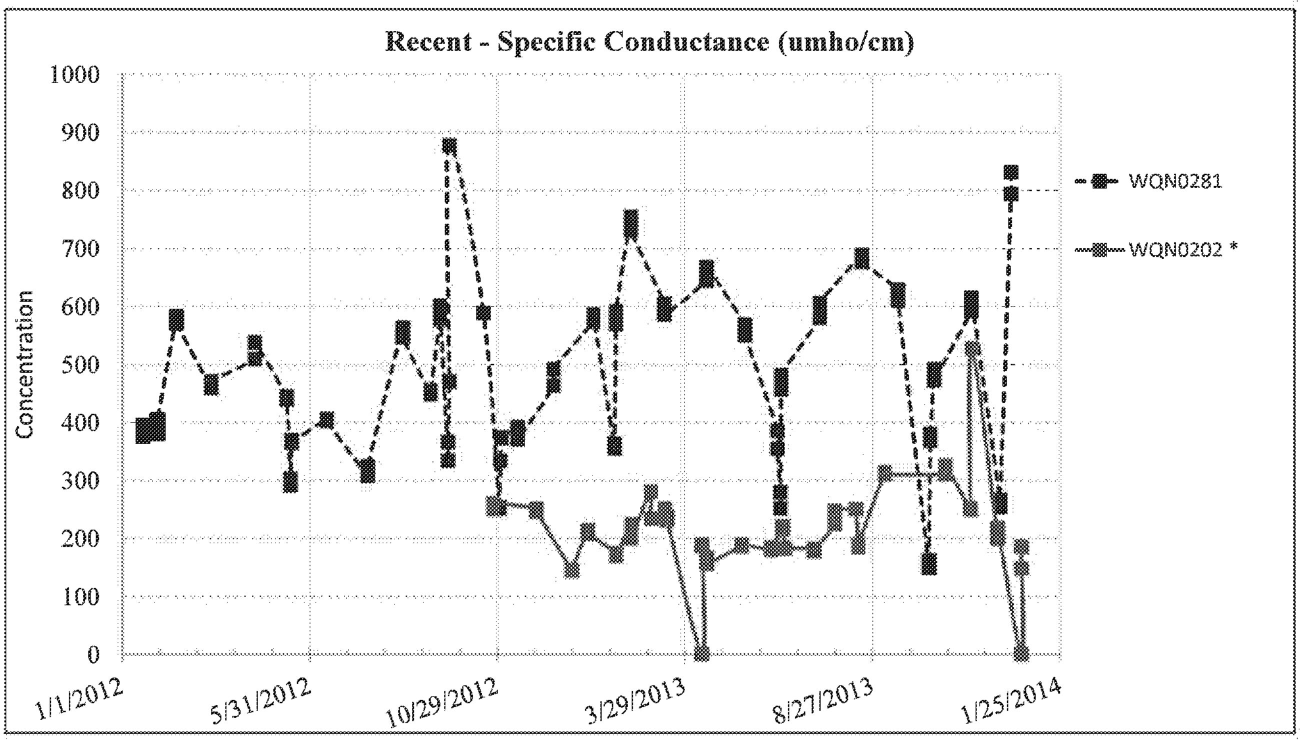

Historical - Osmotic Pressure (milliosmoles/kg)
Concentration
60
50
40
30
20
10
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076
Standard

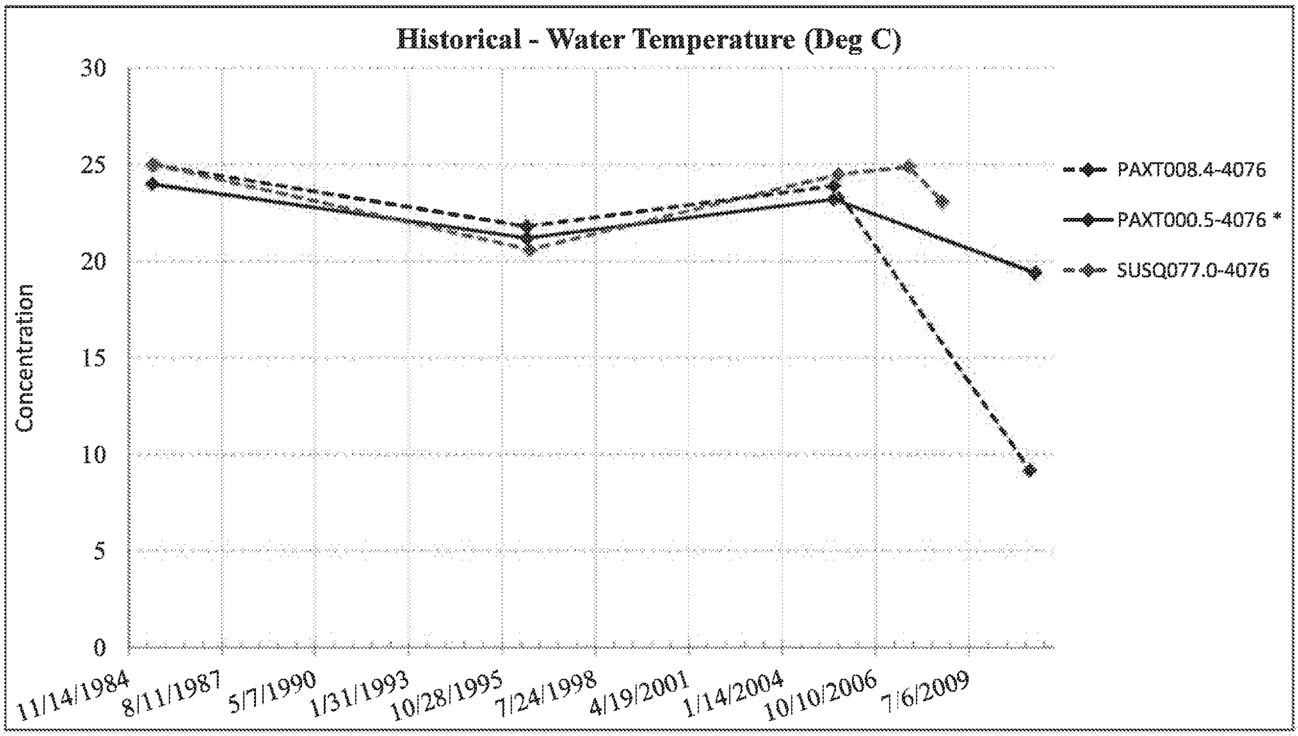

Recent - Osmotic Pressure (milliosmoles/kg)
Concentration
60
50
40
30
20
10
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *
Standard

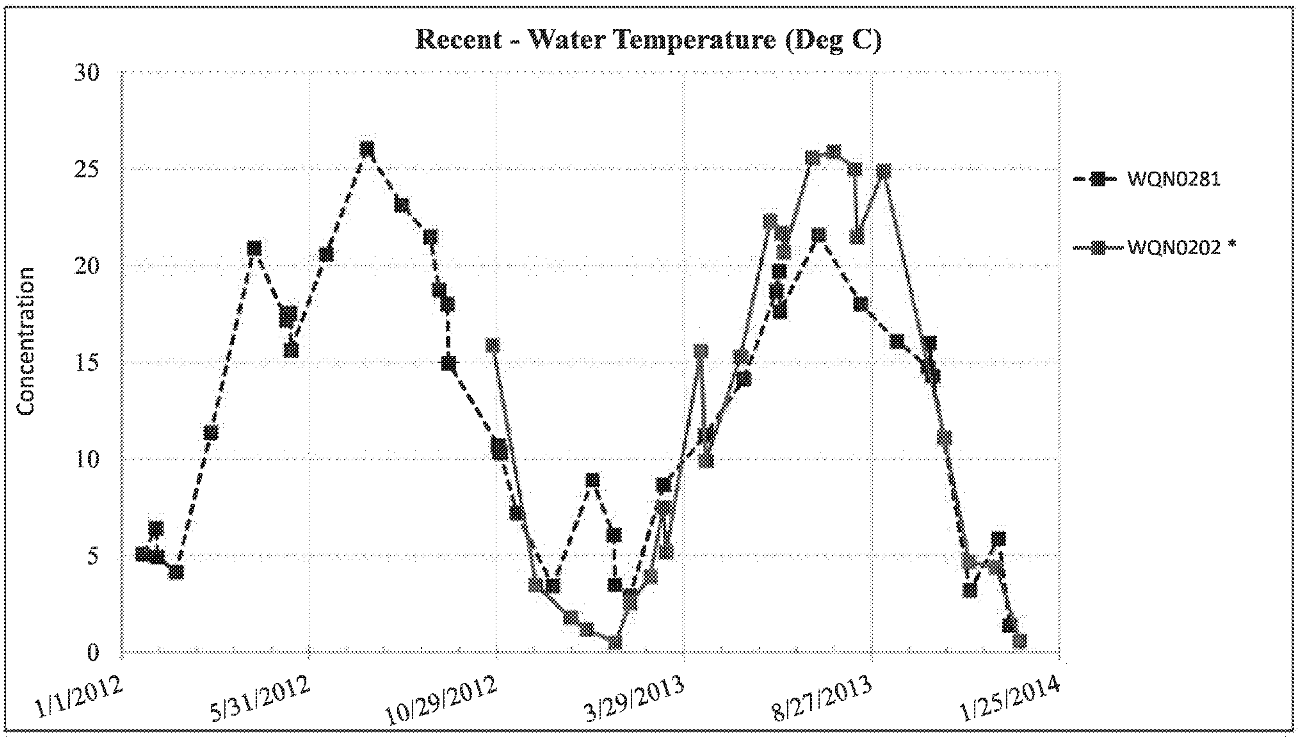

Historical - Turbidity (NTU)
Concentration
0
1
2
3
4
5
6
7
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Turbidity (NTU)
Concentration
0
0.2
0.4
0.6
0.8
1
1.2
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *


Historical - Specific Conductance (umho/cm)
Concentration
1000
900
800
700
600
500
400
300
200
100
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Specific Conductance (umho/cm)
Concentration
1000
900
800
700
600
500
400
300
200
100
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *


Historical - Water Temperature (Deg C)
Concentration
30
25
20
15
10
5
0
11/14/1984
8/11/1987
5/7/1990
1/31/1993
10/28/1995
7/24/1998
4/19/2001
1/14/2004
10/10/2006
7/6/2009
PAXT008.4-4076
PAXT000.5-4076 *
SUSQ077.0-4076


Recent - Water Temperature (Deg C)
Concentration
30
25
20
15
10
5
0
1/1/2012
5/31/2012
10/29/2012
3/29/2013
8/27/2013
1/25/2014
WQN0281
WQN0202 *

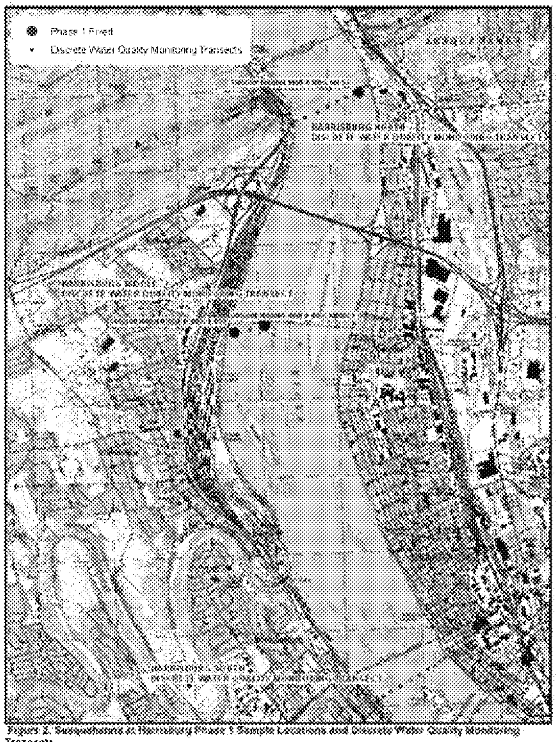


Figure 2. Susquehanna at Harrisburg Phase 1 Sample Locations and Discrete Water Quality Monitoring Transects

Sample Locations

In 2012 the Department established sample locations on the Susquehanna, Juniata and Delaware Rivers. At each sample location, hosts of sampling methodologies were applied. At most sample locations, discrete water quality transects (samples taken at intervals across the width of the river) were established and sampled to determine if the water quality on these wide bodies of water is consistent from one shore to the other. Previous water quality sampling by various agencies documented variable water quality across transects on these rivers. The Department's 2012 discrete transect sampling did indeed characterize variable, cross-transect water quality at many locations. To account for this and to characterize as many of the discernible influences on a given river reach, multiple sample sites were established at each sample location. From this point forward sample or sampling location will be used to describe the general geographical area and sample or sampling site will be used to characterize specific points within or at each sample location.

At the Susquehanna River at Harrisburg sample location, three sample sites were established. One sample site was established approximately 100 meters off the west shore, a second approximately 470 meters off the west shore and near Wade Island, and a third approximately 165 meters off the east shore (Figure 2). These three sample sites were effectively identified as Susquehanna at Harrisburg West, Middle and East. At the Susquehanna at Harrisburg West sample site biologists were able to identify water quality presumably indicative of a Juniata River influence. At the Susquehanna at Harrisburg Middle sample site water quality presumably indicative of the West Branch Susquehanna River was identified, and at the Susquehanna at Harrisburg East sample site water quality indicative of the Susquehanna River mainstem, often referred to as the North Branch, was identified.

Discrete Water Quality Transects

Of the transects sampled, the Susquehanna at Harrisburg sample location exhibited the most discernible differences in water quality overall from the east to west shore. Most notably, difference in specific conductance as high as 139 µS/cm², differences in dissolved oxygen as high as 2.69 mg/l, differences in pH as high as 0.99 SU, and differences in water temperature as high as 4.9°C. The Juniata at Newport sample location had the greatest cross-transect difference in dissolved oxygen of 4.9 mg/l, and the Delaware at Morrisville sample location had a discernible cross-transect difference in dissolved oxygen of 1.72 mg/l.

CIM, Susquehanna at Harrisburg

CIM at Susquehanna River at Harrisburg sample location characterized the most discernible differences in water quality across the three sample sites (Harrisburg West, Middle, East). The least notable difference was temperature (Figure 11), while fluctuations in dissolved oxygen, pH and specific conductance are easily visualized on the following figures (Figures 10, 12 & 13).

Lab Chemistry

Grab samples were collected as composite samples across each of three transects at each Phase 1 Susquehanna at Harrisburg site. Consequentially, there were three water chemistry samples analyzed at all sites giving the Susquehanna Harrisburg sample location a total of nine composited water chemistry grab samples. The results from these nine composited water chemistry grab samples were reviewed. The majority of the values reported for Dissolved Ortho-Phosphorus, Dissolved Phosphorus, Dissolved Nitrite, Total Nitrite, and Total Suspended Solids were less than the detection limit. The results from the three transects were averaged by parameter (Table 2).

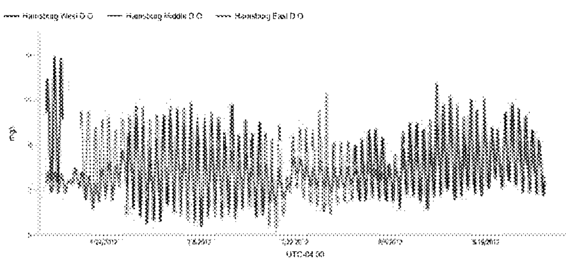


Figure 10. Dissolved Oxygen, Susquehanna at Harrisburg Sample location – 6/14/12-8/31/2012

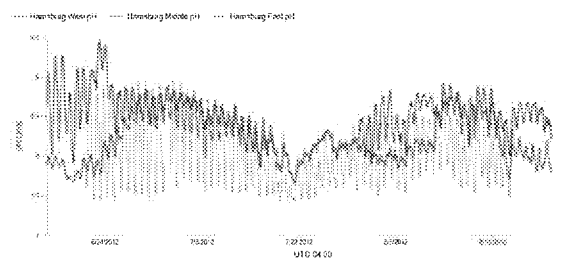


Figure 12. pH, Susquehanna at Harrisburg Sample location – 6/14/12-8/31/2012

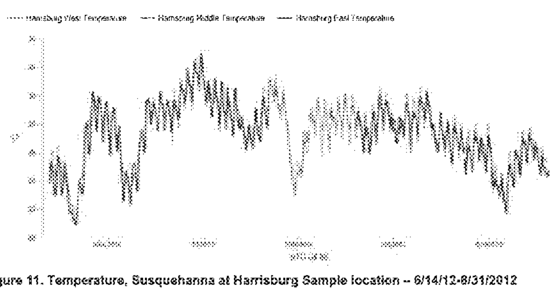


Figure 11. Temperature, Susquehanna at Harrisburg Sample location – 6/14/12-8/31/2012

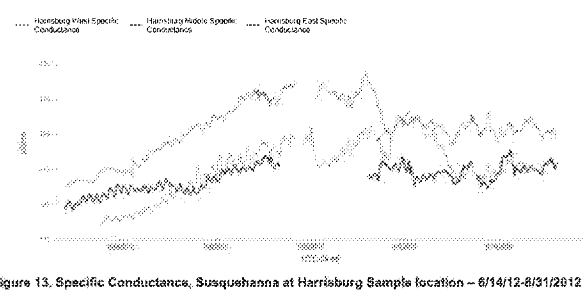
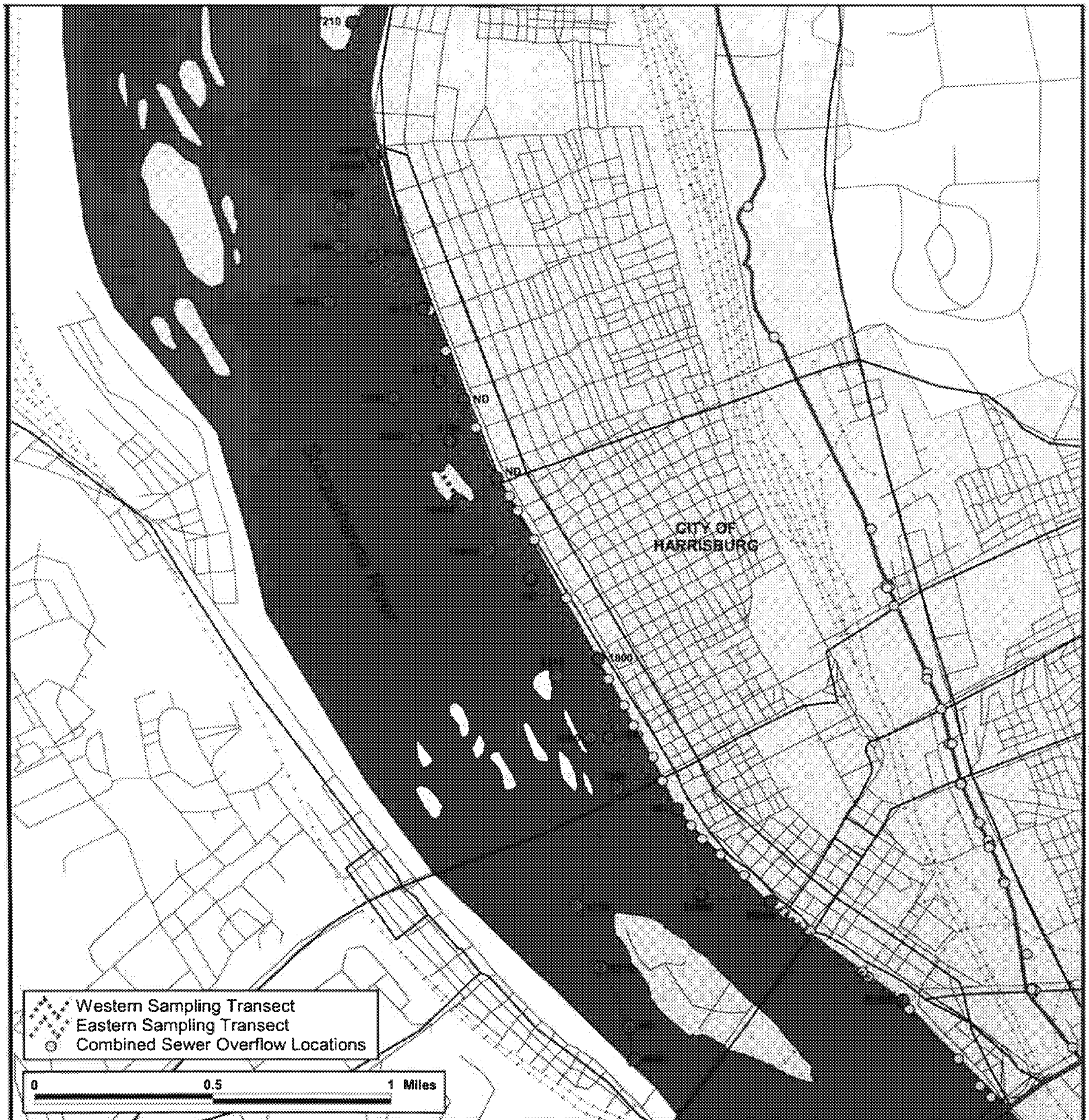


Figure 13. Specific Conductance, Susquehanna at Harrisburg Sample location – 6/14/12-8/31/2012

Location	ORTHO-P DISS	P TOT	P DISS	NO2-N DISS	NO2 TOT	NO3-N DISS	NO3 TOT	N TOT	TSS	N DISS	NH4 DISS	NH4 TOT
Susquehanna Harrisburg West	< 0.010	0.019	0.010	< 0.010	< 0.010	0.433	0.433	0.818	< 5.0	0.753	0.023	0.027
Susquehanna Harrisburg Middle	< 0.010	0.014	< 0.010	< 0.010	< 0.010	0.400	0.397	0.693	< 5.0	0.623	< 0.020	< 0.020
Susquehanna Harrisburg East	< 0.010	0.016	< 0.010	< 0.010	< 0.010	0.233	0.237	0.547	< 5.0	0.477	0.023	0.023

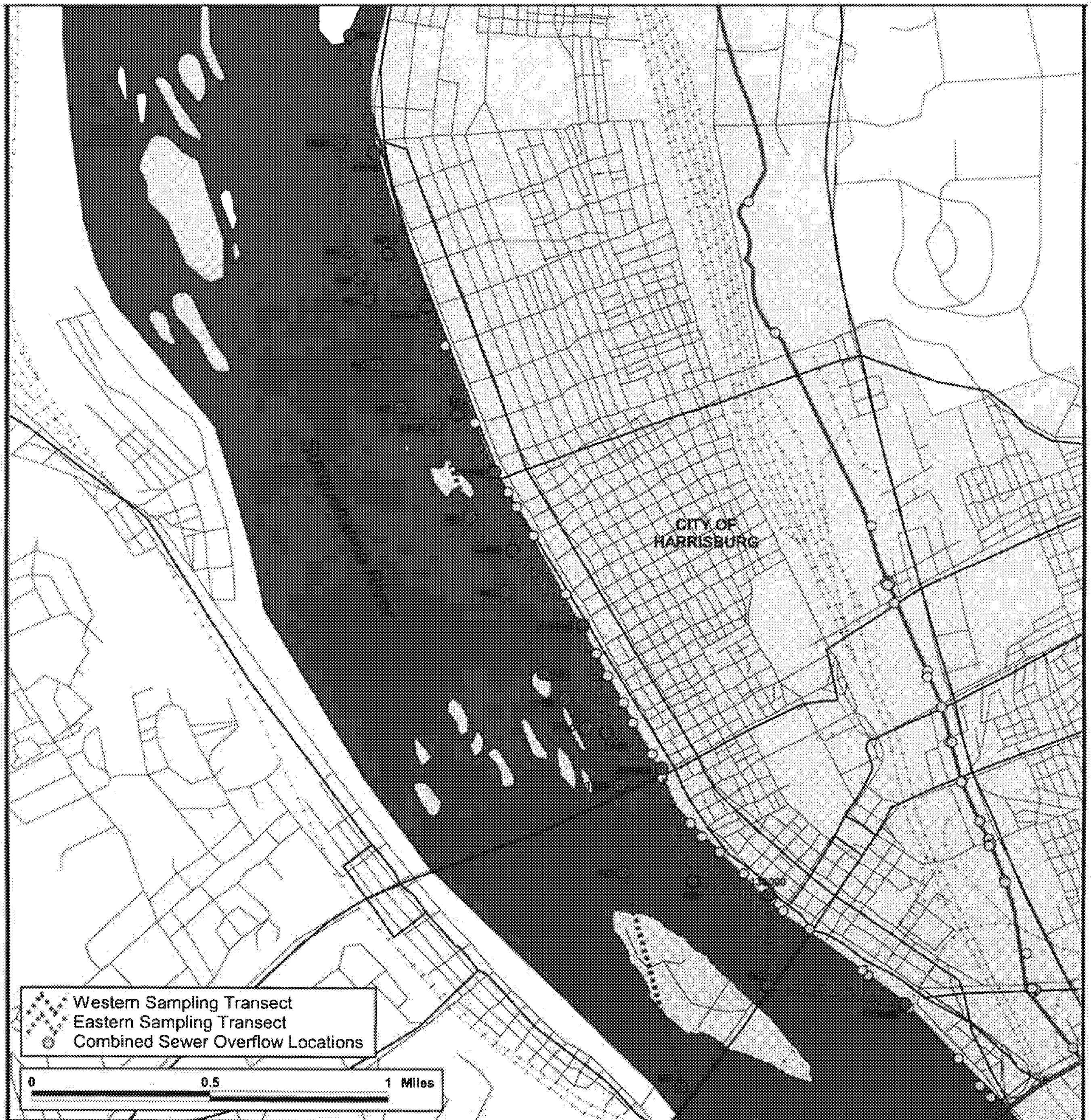
Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



MALCOLM PIRNIE August 2004 4602-006	The Harrisburg Authority Combined Sewer Overflow Management and Control Program Susquehanna River Water Quality Monitoring Plan	Event #1: 7/22/04 T=1 Sampling Pass Fecal Coliform (cfu/100 mL)

f:\projects\4602006\ArcView\projects\event1\fecal_1_hr

Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



MALCOLM PIRNIE August 2004 4602-006	The Harrisburg Authority Combined Sewer Overflow Management and Control Program Susquehanna River Water Quality Monitoring Plan	Event #1: 7/22/04 T=3 Sampling Pass Fecal Coliform (cfu/100 mL)

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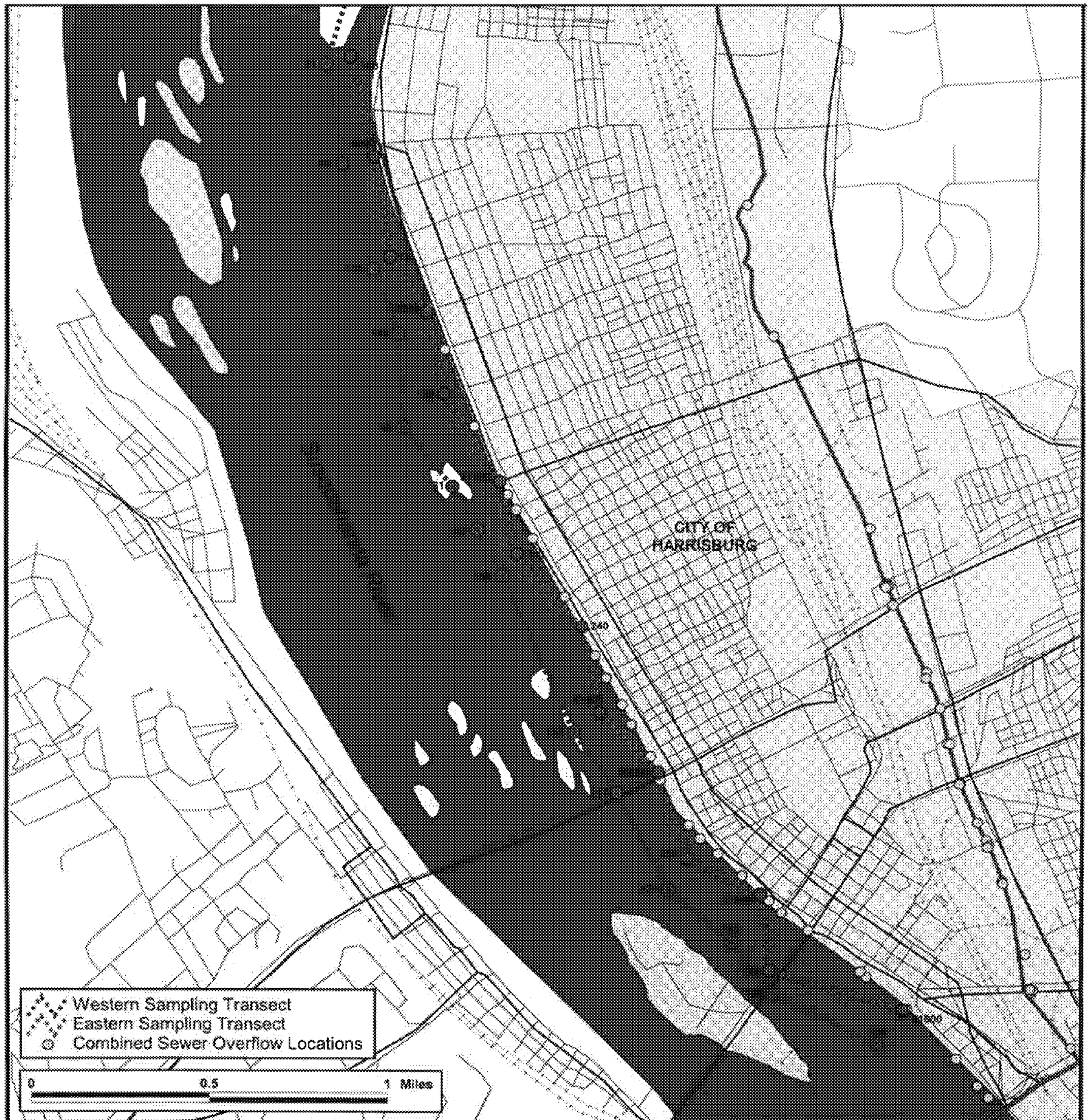
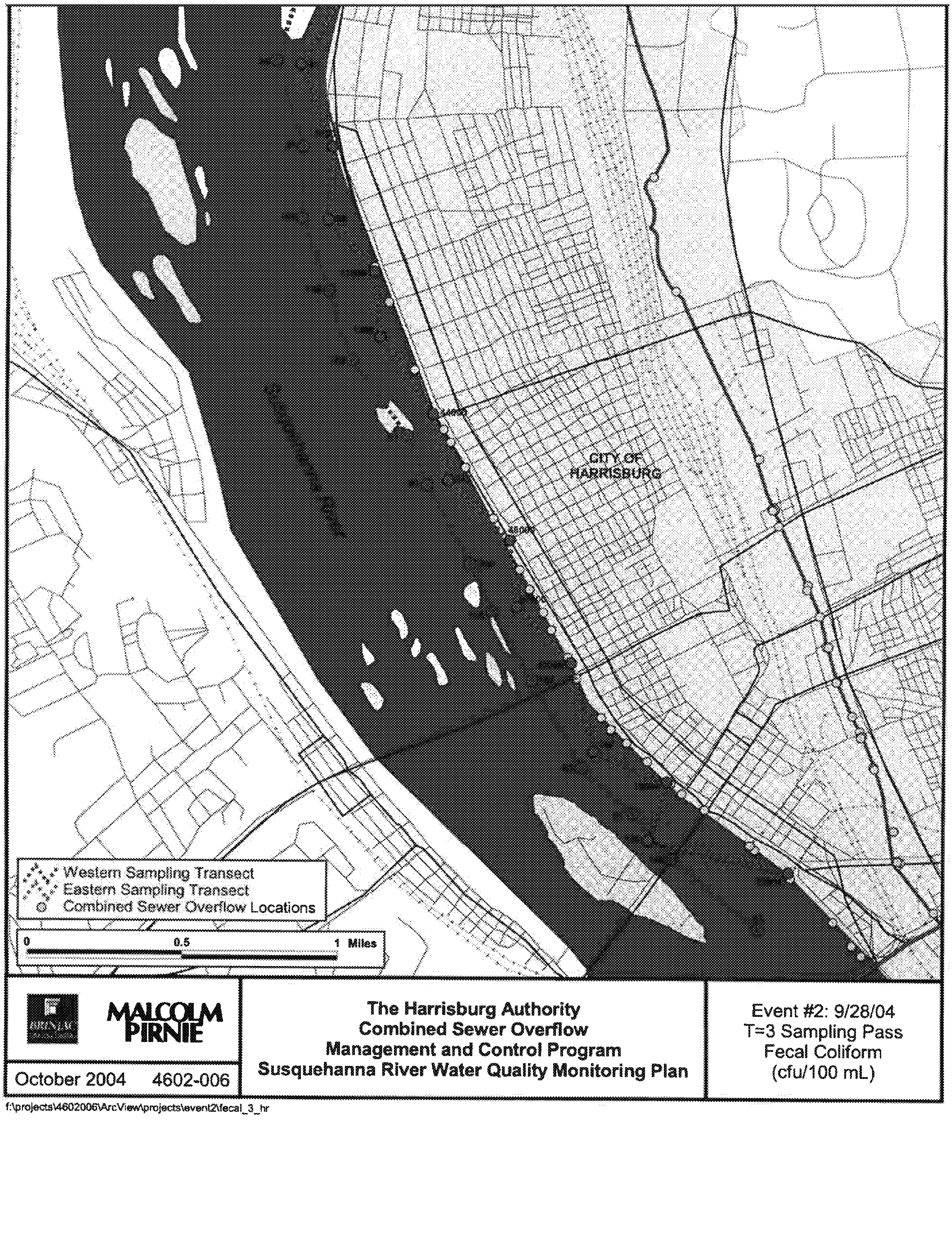
Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



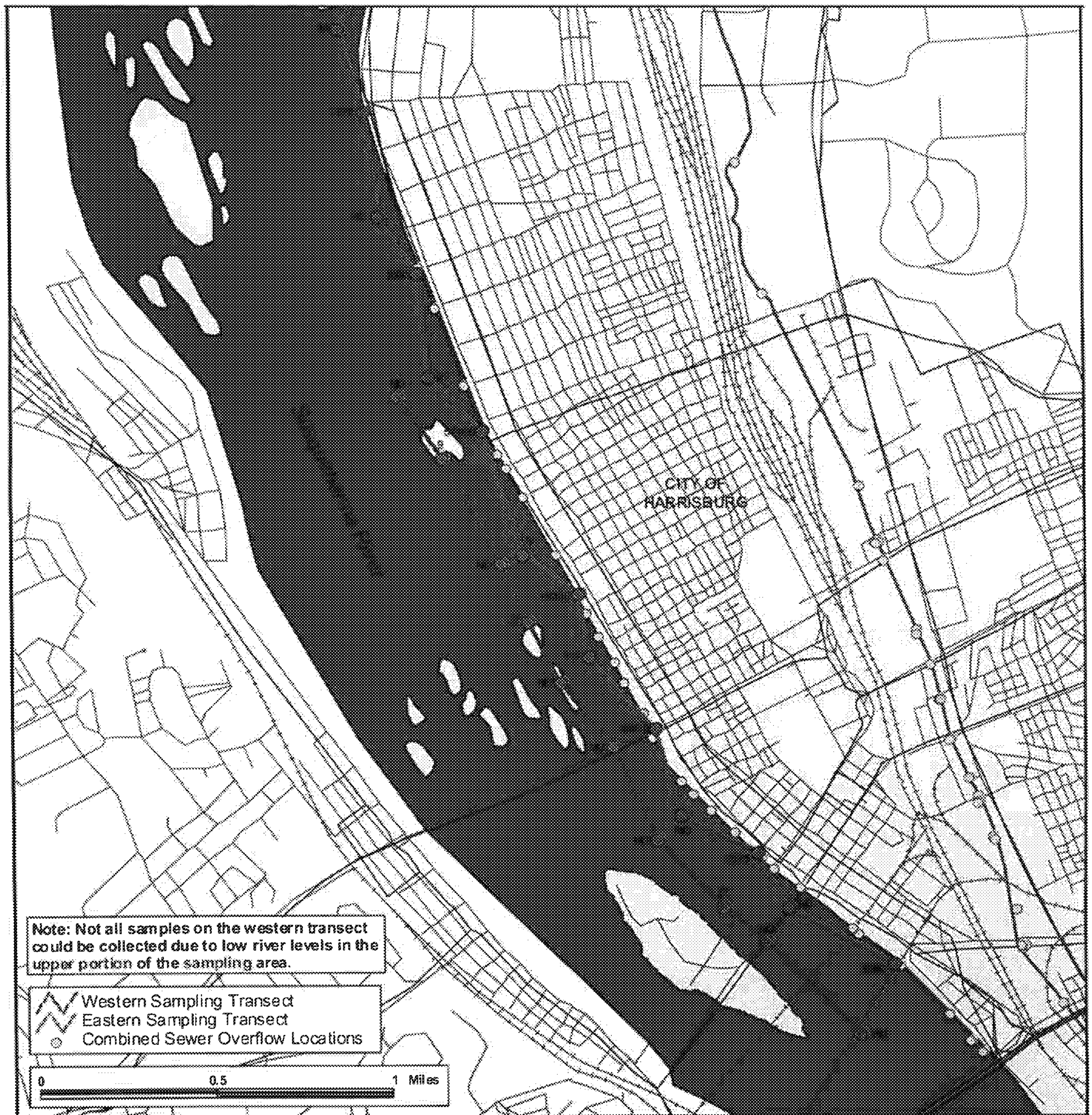
MALCOLM PIRNIE	The Harrisburg Authority Combined Sewer Overflow Management and Control Program Susquehanna River Water Quality Monitoring Plan	Event #2: 9/28/04 T=1 Sampling Pass Fecal Coliform (cfu/100 mL)
October 2004 4602-006		

f:\projects\4602006\ArcView\projects\event2\fecal_1_hr

Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



MALCOLM PIRNIE November 2004 4602-006	The Harrisburg Authority Combined Sewer Overflow Management and Control Program Susquehanna River Water Quality Monitoring Plan	Event #3: 11/04/04 T=1 Sampling Pass Fecal Coliform (cfu/100 mL)

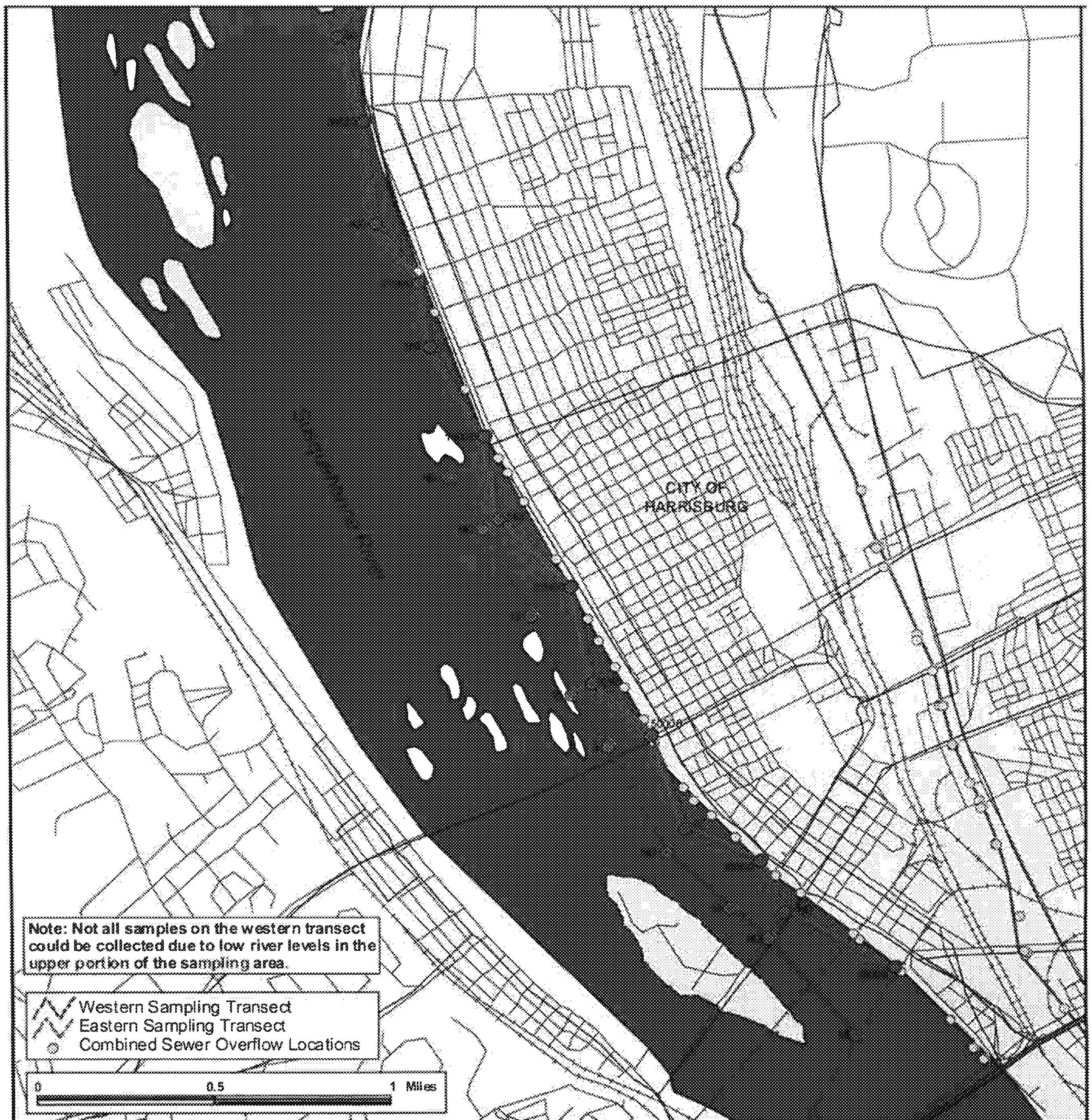
f:\projects\4602006\ArcView\projects\event3\fecal_1_hr

Capital Region Water

Long Term Control Plan Development — **Attachment D**

Susquehanna River Water Quality Assessment — 2005 LTCP Fecal Coliform

Fecal coliform in Susquehanna River following CSO activation from wet-weather event.



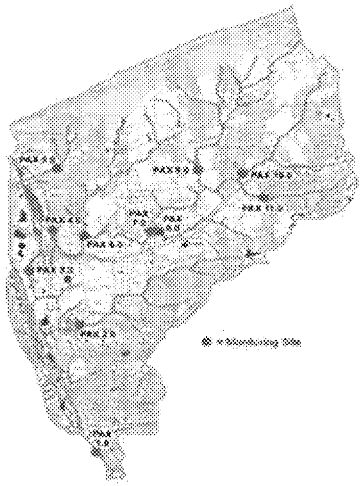
MALCOLM PIRNIE

November 2004 4602-006

The Harrisburg Authority
Combined Sewer Overflow
Management and Control Program
Susquehanna River Water Quality Monitoring Plan

Event #3: 11/04/04
T=3 Sampling Pass
Fecal Coliform
(cfu/100 mL)

f:\projects\4602006\ArcView\projects\event3\fecal_3_hr



Monitoring Sites

PAX 1.0 – Sycamore Street (Paxton Creek)
PAX 2.0 – Harrisburg State Hospital (Asylum Run)
PAX 3.0 – Harrisburg Area Community College (Paxton Creek)
PAX 4.0 – Crooked Hill Road (Paxton Creek)
PAX 5.0 – Fargreen Road (Mountaindale Tributary)
PAX 6.0 – Paxton Church Road (Black Run)
PAX 7.0 – Progress Avenue (Paxton Creek)
PAX 8.0 – Interstate Drive (Devonshire Tributary)
PAX 9.0 – McIntosh Road (Paxton Creek)
PAX 10.0 – Geraldine Road (Linglestown Tributary)
PAX 11.0 – Earl Drive (Paxtonia Tributary)

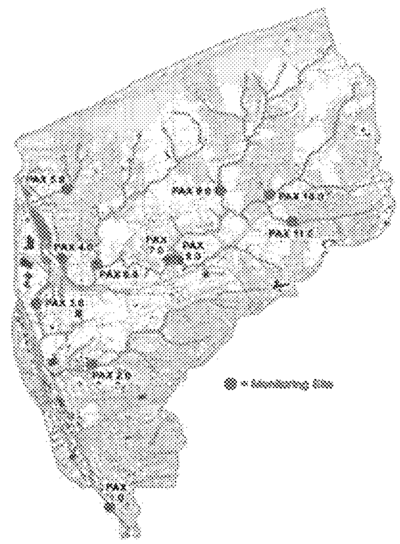
Monitoring Points PAX 1.0 and PAX 3.0 are located downstream of Wildwood Lake on Paxton Creek. PAX 1.0 is located downstream of CRW CSOs.

Table A-4: SRBC Habitat Data

Site	Season	Epifaunal Substrate/ Available Cover	Embeddedness	Velocity/Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency of Riffles	Bank Stability		Vegetative Protection		Riparian Vegetative Zone Width		Total Score
Pax1.0	Fall 06	6	7	11	6	10	0	1	10	10	3	0	2	0	66
	Spring 07	3	12	11	4	13	0	8	9	9	8	0	0	2	83
Pax2.0	Fall 06	11	9	14	9	13	4	16	8	8	4	3	1	1	101
	Spring 07	16	8	14	5	12	19	17	7	6	6	6	9	6	131
Pax3.0	Fall 06	5	7	8	4	9	12	7	8	8	8	8	1	3	84
	Spring 07	6	9	7	2	11	14	5	7	8	8	9	2	3	91
Pax4.0	Fall 06	8	4	8	6	12	7	12	7	7	8	8	2	5	94
	Spring 07	5	3	18	4	18	17	3	8	8	7	10	8	10	111
Pax5.0	Fall 06	13	12	14	11	7	14	16	8	2	9	1	7	1	115
	Spring 07	12	17	14	14	10	17	17	4	1	6	1	9	0	122
Pax6.0	Fall 06	8	6	18	9	8	18	18	3	3	8	9	8	4	111
	Spring 07	18	16	13	13	14	17	16	3	4	4	6	9	6	139
Pax7.0	Fall 06	11	9	12	9	10	7	15	9	9	8	8	4	5	116
	Spring 07	13	11	18	14	18	9	10	8	8	7	6	3	6	127
Pax8.0	Fall 06	9	13	10	14	16	16	16	3	3	7	4	6	2	119
	Spring 07	10	18	14	16	16	17	16	3	2	4	3	3	1	123
Pax9.0	Fall 06	16	6	15	8	11	18	11	8	7	9	8	8	8	133
	Spring 07	16	13	15	10	20	19	15	8	8	10	10	10	5	159
Pax10.0	Fall 06	6	8	14	4	18	14	8	9	7	8	6	6	1	118
	Spring 07	13	8	14	12	15	18	16	5	6	3	5	6	1	122
Pax12.0	Fall 06	17	16	11	12	19	15	17	6	5	6	6	3	2	135
	Spring 07	18	11	13	11	8	19	16	5	5	6	6	6	8	127
BW	Spring 07	20	18	15	18	14	19	18	10	10	10	10	10	10	179

Habitat parameters that were examined along the impaired segment include epifaunal substrate, embeddedness, velocity, sedimentation, channel flow, channel alteration, frequency of riffles, bank stability, vegetation protection, and riparian zone. During each sampling event, parameters were assigned a score from 0 to 20, with 20 indicating optimal conditions, and 0 indicating very poor conditions (Table 1).

Overall, habitat assessment scores from the fall of 2006 and spring 2007 were consistently low at the two monitoring stations in Paxton Creek with scores ranging between 66 and 91 with an average score of 76. Scores for habitat metrics such as epifaunal substrate, embeddedness, sediment deposition, and bank stability, were consistently and considerably low for the monitoring stations in the impaired segment of Paxton Creek.



Monitoring Sites

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PAX 11.0 – Earl Drive (Paxtonia Tributary)
Monitoring Points PAX 1.0 and PAX 3.0 are located downstream of Wildwood Lake on Paxton Creek.
PAX 1.0 is located downstream of CRW CSOs.

The macroinvertebrate monitoring analysis revealed significant differences in the total number of macroinvertebrates and the number of pollution sensitive macroinvertebrates between monitoring stations located within the impaired segment and unimpaired segments of the Paxton Creek:

- High numbers of macroinvertebrates were measured within unimpaired segments (on average 1237), and low numbers (on average 468) of macroinvertebrates within the impaired segments.
- High numbers of sensitive macroinvertebrates (Ephemeroptera, Plecoptera, and Trichoptera) were collected in the unimpaired segments (138) and low numbers in the impaired segment (11).

Table A-5: SRBC Biological Data from Fall 2006

Order	Family	Genus	PAX 1.0	PAX 2.0	PAX 3.0	PAX 4.0	PAX 5.0	PAX 6.0 TOTAL	PAX 7.0	PAX 8.0	PAX 9.0	PAX 10.0	PAX 11.0
Coleoptera	Dytiscidae	*Agabus*											
		Hydroporus											
	Elmidae	*Dubiraphia*			23	1			1		2	2	
		Macronychus				0			0		0	0	
		Optioservus		20	3	154	149	234	5	229	70	114	
		Stenelmis	18	152	8	158	18	83	55	59	22	82	136
	Gyrinidae	*Dineutus*		0		0	0	0	0	0	0	0	0
	Haliplidae	*Peltodytes*		0		0	0	0	0	0	0	0	0
	Hydrophilidae	*Hydrobius*		0		0	2	0	0	0	1	0	0
	Psephenidae	*Ectopria*		0		0	0	0	0	2	1	2	0
		Psephenus		122	1	57	38	16	33	14	6	38	0
Diptera	Ceratopogonidae	*Bezzia*		0		0	0	0	0	0	0	0	0
	Chironomidae		128	152	168	132	8	43	333	142	3	580	132
	Culicidae			0		0	0	0	0	0	0	0	0
	Empididae	*Chelifera*		0		0	0	0	0	0	0	0	0
		Hemerodromia		0		0	0	1	2	0	0	0	1
	Muscidae			0		0	0	0	0	0	0	0	0
	Psychodidae	*Pericoma*	3	0		0	0	0	0	0	0	0	0
	Simuliidae	*Simulium*		24		0	0	36	16	2	1	0	0
	Tipulidae	*Antocha*	1	16		1	2	1	3	38	3	0	1
		Dicranota		0		0	0	0	0	0	0	0	0
		Limnophila		0		0	0	0	0	0	0	0	0
		Tipula	2	3		3	1	0	1	2	0	3	0
Ephemeroptera	Baetidae	*Baetis*		42		3	7	18	9	4	1	4	0
	Caenidae	*Caenis*		0	0	58	0	5	13	3	0	88	0
	Ephemerellidae	*Ephemerella*		0		0	0	0	0	0	0	0	0
		Eurylophella		0		0	0	0	0	0	0	0	0
	Ephemeridae	*Ephemera*		0		1	0	0	0	0	0	0	0
	Heptageniidae	*Leucrocuta*		0		0	0	0	0	0	0	0	0
		Stenacron		0		0	0	1	0	0	0	0	0
		Stenonema		12	1	12	3	3	25	0	18	32	0
	Isonychiidae	*Isonychia*		5		1	0	0	0	0	0	0	0
	Leptophlebiidae	*Paraleptophlebia*		0		0	0	0	0	0	0	0	0
	Tricorythidae	*Tricorythodes*		0		1	0	0	0	0	0	0	0
Megaloptera	Corydalidae	*Nigronia*		0		0	0	0	0	0	0	0	0
Odonata	Aeshnidae	*Boyeria*		6	1	0	0	0	0	0	1	0	0
	Calopterygidae	*Calopteryx*		0		0	2	3	0	0	0	1	0
	Coenagrionidae	*Argia*		0	1	1	0	0	4	0	1	0	1
	Cordulegastridae	*Cordulegaster*		0		0	0	0	0	0	0	0	0
	Gomphidae	*Ophiogomphus*		0		0	2	0	0	0	0	0	0
		Stylogomphus		0		0	0	0	0	0	1	2	0
Plecoptera	Leuctridae	*Leuctra*		0		0	0	0	0	0	0	0	0
	Nemouridae	*Amphinemura*		0		0	0	0	0	0	0	0	0
	Perlidae	*Acroneuria*		0		0	0	0	0	0	0	0	0
		Eccoptura		0		0	0	0	0	0	0	0	0
		Perlesta		0		0	0	0	0	0	0	0	0
	Perlodidae	*Isoperla*		0		0	0	0	0	0	0	0	0
Trichoptera	Glossosomatidae	*Glossosoma*		0		0	0	0	0	0	0	0	0
	Helicopsychidae	*Helicopsyche*		0		0	0	0	0	0	0	0	0
	Hydropsychidae	*Ceratopsyche*		13		3	0	5	0	3	0	0	0
		Cheumatopsyche		2	3	32	86	13	1	5	23	1	7
		Diplectrona		0		0	0	0	0	0	0	0	0
		Hydropsyche		114		4	25	3	1	14	6	2	4
	Hydroptilidae	*Hydroptila*		0		0	0	0	1	0	0	0	0
	Philopotamidae	*Chimarra*		28		69	2	76	46	3	64	136	355
	Polycentropodidae	*Polycentropus*		0	3	0	0	0	0	0	0	0	0
Amphipoda	Gammaridae	*Gammarus*	6	17	28	28	336	41	25	634	37	81	16
Decapoda	Cambaridae	*Orconectes*		0		0		0	0	0	0	0	0
Gastropoda	Ancylidae	*Ferrissia*	1	0		6		0	9	3	0	2	0
	Lymnaeidae	*Fossaria*		0		0		0	0	0	0	0	0
	Physidae	*Physella*		0		2		4	1	1	0	5	0
	Planorbidae	*Gyraulus*		0		0		0	0	0	0	5	0
Hiru.	Erpobdellidae	*Erpobdella*		0		0		0	2	0	0	0	0
		Mooreobdella	5	0	1	0		0	0	0	0	1	0
Isopoda	Asellidae	*Caecidotea*	1	0	55	0		3	0	1	0	0	0
Oligo.	Enchytraeidae			0		0		0	0	0	0	0	0
	Lumbriculidae		1	0		0		1	10	0	0	0	30
	Tubificidae			13		0		0	0	0	0	0	0
Pelecypoda	Corbiculidae	*Corbicula*	1	0	7	26		1	0	0	0	0	0
	Sphaeriidae	*Pisidium*		0		0		0	0	0	0	0	0
Tricladida	Planariidae	*Dugesia*	3	17		5		3	20	1	3	38	28

Table A-6: SRBC Biological Data from Spring 2007

Order	Family	Genus	PAX 1.0	PAX 2.0	PAX 2.0-0	PAX 3.0	PAX 4.0	PAX 5.0	PAX 6.0	PAX 7.0	PAX 8.0	PAX 9.0	PAX 10.0	PAX 12.0	HW
Coleoptera	Dytiscidae	*Agabus*													1
	Elmidae	*Ancyronyx*				4									
		Dubiraphia				55	14		3			8	5		300
		Macronychus				8			8						5
		Optioservus		5	33		85	206	66	95	187	333	323		78
		Stenelmis	2	434	358	30	233	260	94	347	271	332	241	508	355
	Haliplidae	*Peltodytes*													5
	Hydrophilidae	*Helochares*													2
		Tropisternus													
	Psephenidae	*Ectopria*											1		1
		Psephenus		58	49	1	83	34	49	350	46	338	35	1	1
Diptera	Ceratopogonidae	*Probezzia*						1							
		Bezzia					1								8
	Chironomidae		35	583	608	650	553	853	588	525	154	558	882	1566	1583
	Culicidae														4
	Empididae	*Chelifera*			2			5		6	1		8		1
		Hemerodromia					8	4	8	18	3	24	2	1	
	Muscidae														2
	Psychodidae	*Psychoda*	1												
	Simuliidae	*Simulium*		3	6	2	6	28	8	525	8	36	18	28	
	Stratiomyidae	*Nemotelus*						1							
	Tabanidae	*Tabanus*													
	Tipulidae	*Antocha*		4	5		2	16	2	22	21	42	1		
		Hexatoma													
		Limnophila													
		Tipula		1				8	5			2	1	10	12
Ephemeroptera	Baetidae	*Acentrella*								2					
		Baetis					11	8	3	2	1				29
	Caenidae	*Caenis*				50	25	3	21	60	34	60	204		20
	Ephemerellidae	*Ephemerella*					3	13	40			22			
		Eurylophella		1		1		8	8	1	1	8	18		4
	Heptageniidae	*Leucrocuta*				2			5	3					
		Stenacron							8						
		Stenonema				3	33	9	35	31		103	27		35
	Leptophlebiidae	*Paraleptophlebia*													6
	Tricorythidae	*Tricorythodes*					5								
Megaloptera	Corydalidae	*Nigronia*													1
Odonata	Aeshnidae	*Boyeria*				3	3		8	1					12
	Calopterygidae	*Calopteryx*		1	2		1	13	3		3	5	1		18
	Coenagrionidae	*Argia*				1							1		1
	Cordulegastridae	*Cordulegaster*													1
	Gomphidae	*Stylogomphus*						9	3	1		2			13
Plecoptera	Chloroperlidae	*Alloperla*						1							
	Leuctridae	*Leuctra*						13							6
	Nemouridae	*Amphinemura*					1	6	2	1		2	1		3
	Perlidae	*Acroneuria*													2
		Eccoptura													6
		Perlesta					5		8	5		38	8		1
	Perlodidae	*Isoperla*							8			1			
Trichoptera	Glossosomatidae	*Glossosoma*													1
	Helicopsychidae	*Helicopsyche*					2								
	Hydropsychidae	*Ceratopsyche*		3	2				2	1		86			
		Cheumatopsyche		3	2		3	53	53	2		32			388
		Diplectrona						2							1
		Hydropsyche		3	4		5	22		1	35	5	1		3
	Hydroptilidae	*Hydroptila*										2			
	Limnephilidae	*Pycnopsyche*								1					
	Philopotamidae	*Chimarra*		5	5		1	2	31	32	3	23	28	36	23
	Polycentropodidae	*Polycentropus*				1	2								
	Uenoidae	*Neophylax*						5							
Amphipoda	Gammaridae	*Gammarus*		306	64	65	76	1963	67	276	1336	255	119	1	79
Decapoda	Cambaridae	*Cambarus*													
		Orconectes													4
Gastropoda	Ancylidae	*Ferrissia*					2		4	3					
	Lymnaeidae	*Fossaria*				8									
	Physidae	*Physella*				16	2	1		2	1				4
	Planorbidae	*Gyraulus*				4	3	6		2					
Hiru.	Erpobdellidae	*Mooreobdella*				4			3						
	Glossiphoniidae	*Helobdella*											2		
Isopoda	Asellidae	*Caecidotea*		1		66	2		2						
Oligo.	Lumbriculidae		2	2	1	12		4	1	1		2	2	1	
	Tubificidae		26	60	25						325		200		
Pelecypoda	Corbiculidae	*Corbicula*	1			8	8		8			5			
	Sphaeriidae	*Pisidium*				30		2					7		
Tricladida	Planariidae	*Dugesia*					2			8	1	24	14	500	